DEESD
IST-2000-28606
Digital Europe: ebusiness and sustainable development

Virtual dematerialisation: ebusiness and factor X

Final report, March 2003

Kuhndt, M., von Geibler, J., Türk V., Moll, S., Schallaböck, K.O., Steger, S.

Wuppertal Institute

This report constitutes part of Deliverable 6 (D6) of WP3 'Virtual dematerialisation: ebusiness and factor X' of DEESD – Digital Europe: ebusiness and sustainable development

Project funded by the European Community and the "Information Society Technology" Programme

(1998-2002)

Table of Contents

1 INTRODUCTION 6

2 OBJECTIVES AND POLICY BACKGROUND 7

1.1 OBJECTIVES 7
1.2 THE POLICY BACKGROUND 8
1.2.1 The Lisbon Strategy 8
1.2.2 The eEurope initiative 9
1.2.3 The Sustainable Development Strategy (and the 6th Environmental Action Programme) 11
1.2.4 Synergies between "digitalisation" and "dematerialisation" 12

3 ENVIRONMENTAL ASPECTS OF THE ICT SECTOR: THE MACRO-ECONOMIC PERSPECTIVE 15

3.1 INTRODUCTION 15
3.2 THE ROLE OF ICT FROM A MACRO-ECONOMIC PERSPECTIVE 16
3.2.1 Definitions and data 16
3.2.2 Share of ICT on total GDP – structural change 17
3.2.3 Labour 19
3.2.4 Environmental role (CO_2, energy) of ICT 20
3.2.5 Main findings 23
3.3 THE ICT SECTOR'S DIRECT CONTRIBUTION TO OVERALL DECOUPLING – DECOMPOSITION ANALYSES 23
3.3.1 CO_2-emissions 24
3.3.2 Energy use 25
3.3.3 Main findings 26
3.3.4 Indirect effects – the role of ICT for the technical development in the "old" industries 26
3.3.5 Main findings: 28
3.4 CONCLUSIONS OF MACRO-ECONOMIC ANALYSES 28

4 VIRTUAL DEMATERIALISATION: ICT APPLICATION AND ITS DEMATERIALISATION POTENTIAL 31

4.1 INTRODUCTION 31
4.2 RESOURCE CONSUMPTION BY COMMUNICATION INFRASTRUCTURE 33
4.3 RESOURCE CONSUMPTION BY ECOMMERCE 38
4.3.1 Resource consumption by B2C ecommerce 40
4.3.2 Resource consumption by B2B ecommerce 48
4.4 RESOURCE CONSUMPTION BY EGOVERNMENT 53
4.4.1 Internal operations and G2G 54
4.4.2 Government-citizen interactions (G2C) 57
4.4.3 Government-business interactions (G2B) 58
4.5 CONCLUSIONS 59

5 VIRTUAL TRANSPORT? - ICT APPLICATIONS AND TRANSPORT EFFICIENCY 63

5.1 INTRODUCTION TO ICT AND TRANSPORT 63
5.2 TRANSPORT AND B2C ECOMMERCE 66
5.2.1 Limits to transport saving at the micro level 66
5.2.2 Analysis of shopping travel at the macro level 69
5.2.3 Perspectives 70

5.3 TRANSPORT AND TELEWORK 70
5.3.1 Definition of telework *71*
5.3.2 Home-based telework: Experience until now *74*
5.3.3 Future Trends *75*
5.3.4 Mobile telework *79*
5.3.5 Teleconferencing *80*
5.4 CONCLUSIONS 80

6 RECOMMENDATIONS FOR POLICY AND BUSINESS 82

6.1 MONITORING THE ENVIRONMENTAL IMPACTS OF ICT AND EBUSINESS 82
6.2 GREENING ICT HARDWARE 83
6.3 SHIFTING TO ESERVICES 84
6.4 ENABLING TRANSPORT EFFICIENCIES 85
6.5 RAISING AWARENESS AND CHANGING HABITS 87

7 REFERENCES 89

Table of Figures

Figure 1-1: Potential contribution of ICTs to decoupling ‘welfare’ from the use of natural resources. 6

Figure 2-1: Synergies between “digitalisation” and “dematerialisation”. 13

Figure 3-1: Gross Value Added (GVA) in constant 1995 prices by main production sectors – Germany 1991-2000. 19

Figure 3-2: GVA share of ICT compared to other production sectors – Germany 1991 compared to 2000 19

Figure 3-3: Labour (occupied persons) by main production sectors – Germany 1991-2000 20

Figure 3-4: Direct CO2-emissions by main production sectors – Germany 1991-2000 21

Figure 3-5: Direct primary energy use by main production sectors – Germany 1991-2000 21

Figure 4-1: Internet hosts world-wide 34

Figure 4-2: Life cycle of the Internet infrastructure (Source: Wuppertal Institute). 36

Figure 4-3: Phases of commerce (Source Wuppertal Institute). 39

Figure 4-4: Degree of electronic penetration of ecommerce (Source Wuppertal Institute). 39

Figure 4-5: The weight of life styles. Material usage per capita and year in Germany (Source Wuppertal Institute). 46

Figure 4-6: Ecommerce and resource consumption in the product’slife cycle (Source Wuppertal Institute). 47

Figure 4-7: Classifications of B2B forms (Source Wuppertal Institute). 49

Figure 4-8: Influence of electronic communication in B2B on the use of natural resources (Source Wuppertal Institute). 50

Figure 5-1: Main areas of interdependencies between ICT and transport (Source: Wuppertal Institute). 64

Figure 5-2: Main areas for potential spatial work shifts (Source: Wuppertal Institute). 72

Table of Tables

Table 3-1: Definitions of the ICT sector. 17

Table 3-2: ICT sector's gross value added (million Euro in constant 1995 prices) – Germany 1991-2000 (source: Federal Statistical Office 2002). 18

Table 3-3: Direct and cumulated CO_2-emissions and primary energy use by the ICT sector – Germany 1991-1999 22

Table 3-4: Resource productivities based on 4 environmental pressure variables – ICT and total economy, Germany 1991-1999. 23

Table 3-5: Direct CO_2-emissions – decomposition results, Germany 1991-1999 25

Table 3-6: Direct energy use – decomposition results, Germany 1991-1999 25

Table 3-7: Intermediate use of ICT goods and services by selected sectors – Germany 1991-2000 (source: Federal Statistical Office 2002) 28

Table 4-1: Categorisation of resource consumption of ICT applications (adopted from Fichter and Berkhout & Hertin) 32

Table 4-2: B2C shares in sales by product groups, Germany (Gfk 2001, after Vogt, Glaser et.al. (2002), p. 27.) 43

Table 5-1: ECaTT definitions of different kinds of telework. 73

Table 5-2: employed persons by selected professional groups in 1000, Germany, April 2001 (table extract of relevant professional groups. 76

Table 5-3: Future potential for transport savings by home-based telework: Best case (Source: Wuppertal Institute). 77

1 Introduction

At the core of the *Digital Europe* project are three distinct but interlinked research themes (Work Packages). This paper contributes to Work Package 3 (WP3): "Ebusiness and the Environment" (see Section 2 in Detailed Work Plan and Methodology).

WP3 focuses on the impact of ebusiness on two of the most important factors in the creation of a highly resource-productive society:

- the resource intensity of ICT infrastructure and its application and
- its transport efficiency.

One of the major findings of the State of the Art Review was that the contribution of ebusiness to the decoupling of environmental pressure from economic growth (Figure 1-1) is still very much up for discussion, and that quantifiable examples are urgently needed.

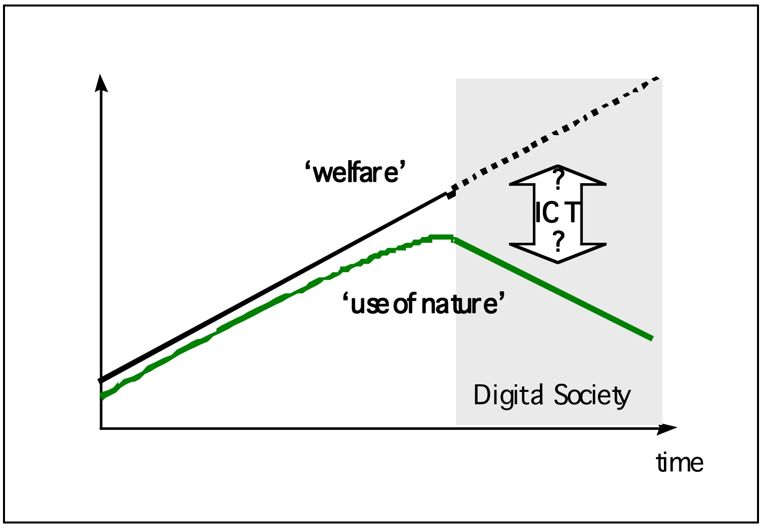


Figure 1-1: Potential contribution of ICTs to decoupling 'welfare' from the use of natural resources.

The research within WP3 contributes to filling this gap by assessing the resource flows and transportation needs on the macro, meso and micro levels. Findings from research conducted in the Digital Europe project are presented in this paper.

The paper starts with a repetition of the objectives of WP3 and a description of the relevant policy background. Chapter 3 presents macro-level analysis of the impact of the ICT sector on environmental sustainability. Chapters 4 and 5 summarise initial findings from the case study work and describe further steps to be taken. Recommendations and overall conclusion are given in chapter 6.

2 Objectives and Policy Background

1.1 Objectives

Based on the findings in the State of the Art Review and considering the overall methodological framework (Soft Systems Methodology), the key objectives within WP 3 (Ebusiness and the Environment) are:

1. Overall: to categorise the impacts of ICT on the environment (chapter 4).
2. On a macro scale: to analyse for selected EU Member States the extent to which ICT and ebusiness may contribute to dematerialisation (chapter 3).
3. On a meso scale: for different ebusiness fields (Business-to-Business (B2B), Business-to-Consumer (B2C) and egovernment) to describe the impacts and opportunities for resource productivity and transport in a qualitative, and where possible quantitative, manner (chapters 4 and 5).
4. On a micro scale: to quantify the impacts of ebusiness on resource productivity and transport in selected case studies (see related case study reports[1]).
5. Overall: to predict likely trends with regard to the dematerialisation potential of ebusiness over the next 3 to 5 years in selected case studies (see related case study reports).
6. Overall: to identify ways in which ICT and ebusiness can contribute to dematerialisation (chapters 3, 4, 5 and 6).
7. Overall: to support policy and decision makers with information regarding the incentives necessary to link ebusiness with the environmental pillar of sustainable development (chapter 6).

Within WP3 a dynamic relationship is given between micro-level research based on detailed case studies with individual project partners (see separate case study report) and macro-level research.

Ultimately, WP3 intends to present findings and recommendations for business and government, to initiate and promote discussion as to how to put in place the right incentives for the environmentally and socially beneficial application of ebusiness.

In order to put forward recommendations regarding the enhancement of the policy framework governing dematerialisation, transport intensity, the ICT sector and ebusiness, the relevant policy background will be described and analysed in the following section

[1] Digital Europe case study report on mobile computing, digital music, ebanking and telework.

1.2 The policy background

This section will provide an overview and analysis of the policy links between the *e*Europe initiative on the one hand and the Sustainable Development strategy (considering also the 6th Environmental Action Programme) on the other. Both are embedded more broadly in the Lisbon strategy.

The overall objective is to analyse the synergies between the eEurope initiative and the EU Sustainable Development strategy, to identify areas for their integration and overcome possible trade-offs.

After a short review of policy developments, a brief analysis of the respective policy objectives is presented and theoretical synergies are worked out. Based on this, a set of research questions is derived, which the empirical research programme undertaken by the Digital Europe project will attempt to answer (work package 3).

1.2.1 The Lisbon Strategy

At the Lisbon European Council (23-24 March 2000) the Union "set itself a new strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion. Achieving this goal requires an overall strategy (later entitled "Lisbon Strategy") aimed at:

- preparing the transition to a knowledge-based economy and society with better policies for the information society and Research and Development, as well as stepping up the process of structural reform for competitiveness and innovation and completing the internal market;

- modernising the European social model, investing in people and combating social exclusion;

- sustaining a healthy economic outlook and favourable growth prospects by applying an appropriate macro-economic policy mix." (Lisbon Presidency Conclusions)

The Lisbon strategy integrated economic and social matters, with a clearly observed emphasis on the "new economy". The Sustainable Development strategy, including an environmental dimension, was added to the Lisbon Strategy at the Gothenburg European Council in June 2001[2].

The Lisbon process is being reviewed in the context of annual Spring European Council meetings. For each Spring Council a so-called "synthesis report" showing progress towards the implementation of the Lisbon Strategy is presented. A list of "structural indicators" has been developed to meet these reporting obligations in five policy domains: employment, innovation, economic reform, social cohesion, and the environment.

---

[2] Commission Proposal COM(2001) 264 final. A Sustainable Europe for a Better Worl: A European Union Strategy for Sustainable Development. adopted by the European Council in Gothenburg in June 2001.

1.2.2 The eEurope initiative

In December 1999 the European Commission launched the eEurope[3] initiative to bring all Europeans into the digital age, with the following key objectives:

Creating a digitally literate Europe, supported by an entrepreneurial culture.

Ensuring the process is socially inclusive and builds consumer trust.

In light of the Lisbon Strategy, the European Council held in Lisbon also invited the Council and the Commission to draw up "…a comprehensive eEurope Action Plan". In response to this endorsement the Commission adopted a draft Action Plan on 24th May 2000 in which 10 actions were clustered along three objectives.

1. A cheaper, faster and secure Internet:

    a) Cheaper and faster Internet access;

    b) Faster Internet for researchers and students;

    c) Secure networks and smart cards.

2. Investing in people and skills:

    a) Bringing European youth into the digital age;

    b) Working in the knowledge-based economy;

    c) Participation for all in the knowledge-based economy.

3. Stimulating the use of the Internet:

    a) Accelerating ecommerce;

    b) Government online: electronic access to public services;

    c) Health online;

    d) European digital content for global networks;

    e) Intelligent transport systems.

ICT and ebusiness are supposed to have significant positive impact on economic development in the EU as "...the increased use of ICT leads to productivity gains

[3] Commission of the European Communities. (2000). eEurope An Information Society for all – Communication on a CommissionInitiative for the Special Council of Lisbon, 23 and 24 March 2000.

and hence improves the competitiveness of enterprises and the economy as a whole, leading to higher economic growth than otherwise achievable."[4].

The Commission has therefore committed itself to maximising the benefits of the e-economy to European enterprises by fostering a culture of entrepreneurship and innovation, enhancing the ICT skills necessary to participate effectively in the e-economy, increasing the ability of European enterprises to compete in a modern global economy, and further improving the functioning of the internal market.

A progress report presenting an update of the eEurope initiative was prepared for the Nice Council meeting and the eEurope 2002 initiative was recently superceded by the eEurope 2005 Action Plan. "The objective of the new Action Plan is:

- to provide a favourable environment for private investment and for the creation of new jobs,
- to boost productivity,
- to modernise public services, and
- to give everyone the opportunity to participate in the global information society.

eEurope 2005 therefore aims to stimulate secure services, applications and content based on a widely available broadband infrastructure."[5].

The eEurope action plan is based on two groups of actions that reinforce each other. Firstly, it aims to stimulate services, applications and content, covering both online public services and ebusiness. Secondly, it addresses the underlying broadband infrastructure and security matters. By 2005, Europe should have[6]:

- modern online public services, i.e. egovernment, elearning services and ehealth services;
- a dynamic ebusiness environment;
- and, as an enabler for these:
- widespread availability of broadband access at competitive prices;
- a secure information infrastructure.

---

[4] Commission of the European Communities (2001): Communication from the Commission to the Council and the European Parliament – The Impact of The e-Economy on European Enterprises: Economic Analysis and Policy Implications, COM (2001) 711 final, Brussels, 29.11.2001, p. 21.

[5] Commission of the European Communities (2001): Communication from the Commission to the Council, the European Parliament and the Economic and Social Committee and the Committee of the Regions: *eEurope 2005 - An Action Plan to be presented in view of the Sevilla European Council - 21/22 June 2002, COM (2002) 263, p. 2*

[6] COM(2002) 263, p. 3.

When the eEurope initiative was launched in 2000, it was rather detached from the issue of Sustainable Development (and the environment): environmental issues are not addressed in the related policy documents at all. However, the eEurope initiative has always been closely linked with the Lisbon strategy, which started off at the same time and provided the overarching goal for Europe to "become the most competitive and dynamic knowledge-based economy in the world". After the Sustainable Development strategy became part of the Lisbon strategy, the issues of the e-economy and sustainability have become closer.

1.2.3 The Sustainable Development Strategy (and the 6th Environmental Action Programme)

At the Gothenburg summit the European Council agreed a strategy for sustainable development which completes the Union's political commitment to economic and social renewal, and adds a third environmental dimension to the Lisbon strategy.

Beside two socio-economic objectives, as already identified by the Lisbon strategy[7], the Sustainable Development strategy focuses on four further major objectives, namely:

- Limiting climate change and increasing the use of clean energy;
- Addressing threats to public health;
- Managing natural resources more responsibly;
- Improving the transport system and land-use management.

As regards sustainable resource management, the Sustainability Strategy formulates the headline objective to break the links between economic growth, the use of resources and the generation of waste.

The 6th Environmental Action Programme contains the following objectives with regards to resource use:

- to ensure that the consumption of renewable and non-renewable resources and associated impacts do not exceed the carrying capacity of the environment, and
- to achieve a decoupling of resource use from economic growth, through significantly improved resource efficiency, dematerialisation of the economy, and waste prevention.
- As regards transport, the main headline objectives in the Sustainability Strategy are:
- to decouple transport growth significantly from growth in Gross Domestic Product in order to reduce congestion and other negative side-effects of transport.

[7] Combat poverty and social exclusion; deal with the economic and social implications of an ageing society.

- to bring about a shift in transport use from road to rail, water and public passenger transport so that the share of road transport in 2010 is no greater than in 1998.

- to implement in 2003 a framework ensuring, through the use of intelligent transport systems, the interoperability of payment systems for road transport, and to promote further technological progress to enable the introduction of road pricing.

- to promote teleworking by accelerating investments in next generation communications infrastructure and services.

It was decided at the Stockholm European Council that the EU sustainable development strategy should complete and build on the political commitment represented by the Lisbon strategy, by including an environmental dimension. According to the Council, this recognises that in the long term, economic growth, social cohesion and environmental protection must go hand in hand. Moreover, with regards to synergies between environmental, economic and social objectives, the Gothenburg presidency conclusions state: "clear and stable objectives for sustainable development will present significant economic opportunities. This has the potential to unleash a new wave of technological innovation and investment, generating growth and employment. The European Council invites industry to take part in the development and wider use of new environmentally friendly technologies in sectors such as energy and transport. In this context the European Council stresses the importance of decoupling economic growth from resource use." (Gothenburg Presidency Conclusions, p. 4).

The Sustainable Development strategy states that "decoupling environmental degradation and resource consumption from economic and social development requires a major reorientation of public and private investment towards new, environmentally friendly technologies. The sustainable development strategy should be a catalyst for policy-makers and public opinion in the coming years and become a driving force for institutional reform, and for changes in corporate and consumer behaviour. Clear, stable, long-term objectives will shape expectations and create the conditions in which businesses have the confidence to invest in innovative solutions, and to create new, high-quality jobs." Thus the strategy outlines the major link between environmental and socio-economic prospects, i.e. technological development benefiting both objectives.

1.2.4 Synergies between "digitalisation" and "dematerialisation"

From a policy analysis point of view, three strands of EU policy objectives – all integrated in the "Lisbon strategy" – seem to be relevant for the issue of 'ebusiness and environment' as addressed by the Digital Europe project:

1. to foster productivity growth leading to sustainable economic growth by strengthening the e-economy (as addressed in the eEurope initiative);

2. to increase resource productivity in order to decouple economic growth from the use of natural resources through dematerialisation, (as addressed in the Sustainability Strategy and in particular in the key environmental priority area

"natural resources and waste" within the 6th Environmental Action Programme (EAP);

3. to integrate environmental concerns into transport policies through a decoupling of economic growth and transport growth and to implement intelligent transport systems.

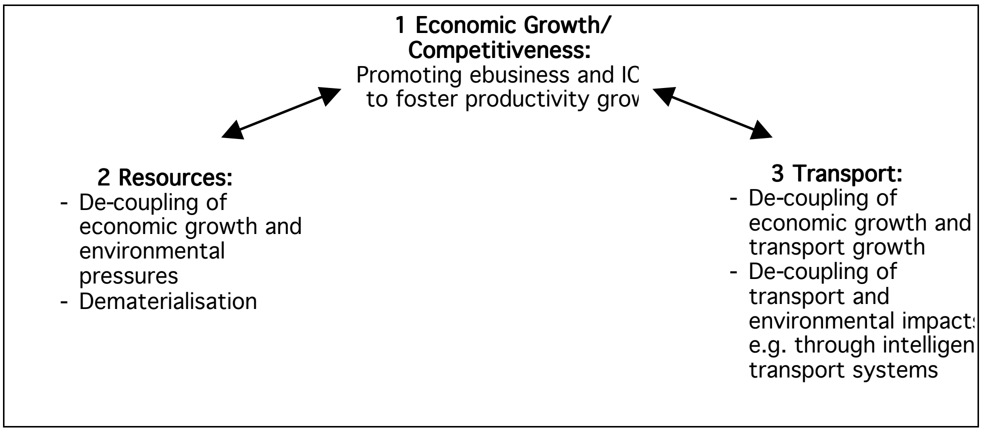


Figure 2-1: Synergies between "digitalisation" and "dematerialisation".

Synergies between 1 and 2

New markets for dematerialised goods and services will arise. The "new economy" is less resource intensive than the "old economy", so if the "new economy" increases its share of total value added, this implies an overall structural change towards a less resource intensity at the macro-economic level. Such "new" goods and services – being less resource intensive – can even replace material goods (e.g. T-NetBox), but the potential to substitute traditional material goods through new ICT-based services is still unknown and will have to be addressed by more detailed analysis.

ICT is contributing to technological innovations in the "old economy", and so for example improving the resource efficiency of manufacturing processes and energy transformation processes, leading to reduced resource requirements per unit value added in those old sectors. Ebusiness and ICT should also support dematerialisation in terms of optimising intermediate economic transactions through B2B.

Synergies between 1 and 3.

New markets for dematerialised goods and services will reduce the volume of transport, particularly "heavy" freight transport. The "new" goods and services will increasingly be traded over the Internet, which is less resource intensive *per se* than traditional methods of distribution.

ICT will contribute to making transport infrastructure more intelligent, and hence reduce the environmental load per transport unit.

Possible trade-offs between the productivity-growth objective and the environmental/ transport objectives relate to the so-called "rebound effect" and also need to be studied further. For example the increased consumption of "new" goods and services can offset the positive effects mentioned above. The e-economy might also induce additional passenger and freight transport, which again can offset the positive effects.

The strategy underlines the strong belief of European policy-makers that synergies between strategic objectives override possible negative trade-offs. This has to be further verified by the Digital Europe research agenda and demonstrated through best practice examples.

3 Environmental aspects of the ICT sector: the macro-economic perspective

3.1 Introduction

The key objective of the ‘macro-analysis-module’ within the *Digital Europe* project is to quantify the potential contribution of *e*business and ICT to dematerialisation and resource productivity.

The macro-economic analysis follows a top-down approach complementary to the case-study based micro analyses. The objective is to analyse energy use and selected material flows (CO_2) of three EU Member States to determine whether there is any macro-level evidence of dematerialisation and increased resource productivity resulting from *e*business and ICT.

There are two principal possibilities of determining how far *e*business and ICT can contribute to de-linking or dematerialisation from a macro-economic perspective:

1. through an economic structural change, i.e. the relatively less resource-intensive ICT sector gains a higher share of total GDP;

2. through support to other economic sectors to become more eco-efficient (secondary and tertiary effects).

The first area has been extensively analysed in the first phase of the project for the UK, Germany and Italy (see interim report). This final report re-emphasises the conclusions from the first phase based on extended analyses of German data which have become available in the intervening period. It then focuses on the second area – indirect effects.

Macro-economic analysis tools are heavily dependent on the availability of adequate statistical information. So far, the statistical basis is weak (particularly EU-wide), because

- the statistical definition of the ICT sector is limited (there is an ongoing expert discussion as to whether statistical classifications should be modified in order to provide adequate information on the ICT sector. However, it will take decades before data will be available from modified statistical systems); and

- integrated environmental and economic statistics (e.g. NAMEA) are still limited with regards to time coverage and range of environmental indicators.

Nevertheless, the “top-down” research question seems to be particularly important which justifies analysing the situation despite the limitations of the data. It is the synthesis with the “bottom-up approaches also used in this work package which, in the end, will have to determine whether the Lisbon strategy for the *e*-economy contradicts environmentally sustainable development or not.

The hypothesis, stemming from macro-economic analyses, is that there seems to be no trade-off between the e-economy strategy and environmental sustainability.

The effects of the *e*-economy strategy are most probably neutral with regards to the environmental dimension of sustainable development.

3.2 The role of ICT from a macro-economic perspective

3.2.1 Definitions and data

The statistical definition of the ICT sector used in this study is based on an OECD publication[8]. The OECD uses a definition of the ICT sector which was agreed at the April 1998 meeting of the Working Party on Indicators for the Information Society (WPIIS) and subsequently endorsed and made public at the September 1998 meeting of the Committee for Information, Computer and Communications Policy. Adoption of these principles led to a definition based on the industrial classes of revision 3 of the International Standard Industrial Classification (ISIC).

The 4-digit level of ISIC classes is much more detailed than the NACE 2-digit divisions as available in NAMEAs. For this study, the respective ISIC classes (4-digit level) were related to 2-digit NACE divisions as illustrated in the following overview:

[8] OECD (2000). *Measuring the ICT Sector*. OECD, Paris 2000.

Table 3-1: Definitions of the ICT sector.

OECD definition of ICT sector ISIC 4-digit classes		Definition used in this study NACE 2-digit divisions		Comments
3000	Office, accounting and computing machinery	30	Manufacture of office machinery and computers	
3130	Insulated wire and cable			not used since NACE 2-digit division is too broad
3210	Electronic valves and tubes and other electronic components	32	Manufacture of radio, television and communication equipment and apparatus	
3220	Television and radio transmitters and apparatus for line telephony and line telegraphy			
3230	Television and radio receivers, sound or video recording or reproducing apparatus, and associated goods			
3312	Instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process equipment	33	Manufacture of medical, precision and optical instruments, watches and clocks	
3313	Industrial process control equipment			
5150	Wholesaling of machinery, equipment and supplies			not used since NACE 2-digit division is too broad
6420	Telecommunications	64	Post and telecommunications	
7123	Renting of office machinery and equipment (including computers)			not used since NACE 2-digit division is too broad
72	Computer and related activities	72	Computer and related activities	

In the interim report, NAMEAs were analysed for Germany, UK and Italy but analysis was limited with regards to time coverage and number of environmental variables (see interim report). In the intervening period, the Federal Statistical Office in Germany has made more comprehensive data sets available, namely annual input-output tables (in current and constant prices) for the period 1991 to 2000 and material flow accounts for direct and indirect CO_2-emissions and energy use for the period 1991 to 1999. In this final report, these data sets were used to conduct the same analyses as in the interim report. The detailed description of the applied methodologies can be found in the interim report.

3.2.2 Share of ICT on total GDP – structural change

In Germany, the economic importance of the ICT sector has been rising throughout the 1990s. Between 1991 and 2000, the ICT sector's gross value added (in constant

1995 prices) increased by almost 50 per cent from 76,709 to 112,660 million Euro (Figure 3-1). With 6.7 per cent, the average annual growth rate of the ICT sector was considerably higher than the overall economic growth rate of 1.7 per cent (annual average between 1991 and 2000). Almost half of the ICT sector's gross value added (around 45 per cent) is allocated to the post and telecommunication sector which almost doubled its gross value added from 35 to 66 billion Euros (Table 3-2). With an average annual growth rate of 10.6 per cent, computer services showed the highest growth within the ICT sector.

Table 3-2: ICT sector's gross value added (million Euro in constant 1995 prices) – Germany 1991-2000 (source: Federal Statistical Office 2002).

	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Manufacture of office machinery and computers	2.843	2.169	2.629	2.745	3.099	2.902	3.486	4.203	3.924	4.595
Manufacture of radio, television and communication equipment and apparatus	8.645	8.599	8.241	8.762	7.267	8.394	8.934	9.335	12.190	15.429
Manufacture of medical, precision and optical instruments, watches and clocks	15.907	16.635	14.970	14.612	13.454	13.683	13.649	13.633	13.755	15.264
Post and telecommunications	35.253	37.482	37.731	38.714	40.168	42.195	45.379	49.280	61.027	66.354
Computer and related activities	15.942	16.824	18.547	19.345	20.706	23.051	26.201	32.136	34.818	39.331
ICT total	78.590	81.709	82.118	84.178	84.694	90.225	97.649	108.587	125.714	140.973

At the end of the decade, the ICT sector's share of the gross value added of the total economy (i.e. GDP[9]) amounted to almost 8 per cent. Although it has been rising throughout the 1990s, the ICT sector's importance is still moderate – its weight can be compared with the construction sector (Figure 2-1). Together with the financial services sector it is one of the "winners" of an overall economic structural change in Germany. In contrast, the industry (excluding ICT) sector reduced its shares.

[9] The gross value added of the total economy is comparable to the GDP (gross domestic product), though the calculation method differs.

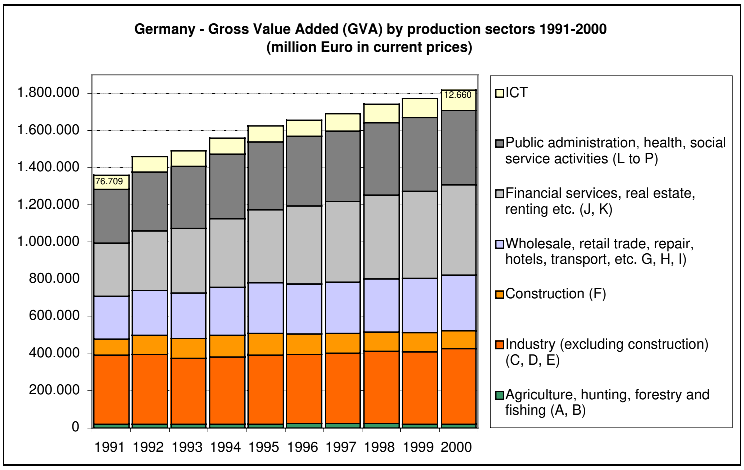


Figure 3-1: Gross Value Added (GVA) in constant 1995 prices by main production sectors – Germany 1991-2000.

Source: Federal Statistical Office Germany 2002

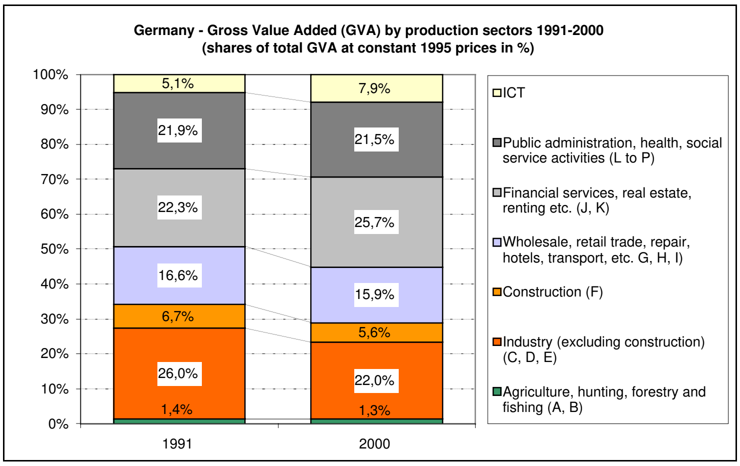


Figure 3-2: GVA share of ICT compared to other production sectors – Germany 1991 compared to 2000

Source: Federal Statistical Office Germany 2002

3.2.3 Labour

In 1999, 1,439 million individuals were employed in the ICT sector. Despite its strong growth in terms of gross value added, labour in 1999 was less than in 1991 when 1,817 million individuals were occupied in the ICT sector (annual change rate: -2.9 per cent). Within the ICT sector, the manufacture of office machinery and computers saw the strongest decline in labour (-60 per cent between 1991 and 1999) whereas labour in computer services, etc., increased by 60 per cent.

Compared with the rest of the economy, the ICT sector had a stronger annual decline in labour (-2.9 per cent) than the total economy (-0.1 per cent) which actually remained almost constant. Clearly, the ICT sector could not compensate for the loss of labour in the industry and construction sectors. Employment growth took place in the financial services and public administration sectors (Figure 3-3). The ICT sector's ambivalent trends – i.e. strong value added growth but declining employment – resulted in extraordinary growth of labour productivity. Between 1991 and 1999, labour productivity doubled from 43 to 87 thousand Euros per occupied person with an annual growth rate of 9.2 per cent.

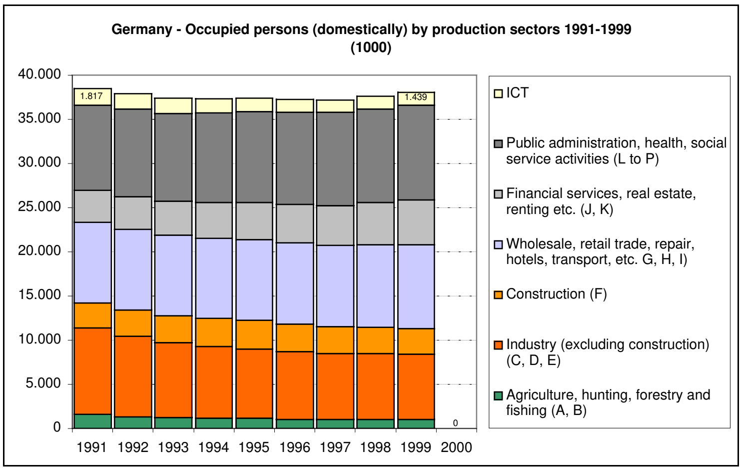


Figure 3-3: Labour (occupied persons) by main production sectors – Germany 1991-2000

Source: Federal Statistical Office Germany 2002

3.2.4 Environmental role (CO_2, energy) of ICT

Both CO_2-emissions and primary energy use decoupled from economic growth in the production sector of the German national economy between 1991 and 1999 (Figure 3-4 and Figure 3-5).

Between 1991 and 1999, the direct CO_2-emissions of the German production sector[10] decreased by almost 15 per cent from 757 to 647 million tonnes. The overall absolute decoupling was clearly caused by the 20 per cent reduction – some 100 million tonnes – in the size of the industry sector.

Primary energy use in the German production sector (excluding private households) also declined absolutely throughout the 1990s from 10,700 to 9,997 Peta Joule. However, with -6.6 per cent the reduction was less pronounced than with CO_2. Again, the industry sector was mainly responsible for the absolute reduction in energy use (-840 PJ) whereas the tertiary sector increased direct energy use by about 240 PJ.

[10] In addition, some 210-220 million tonnes CO_2 were emitted by private households.

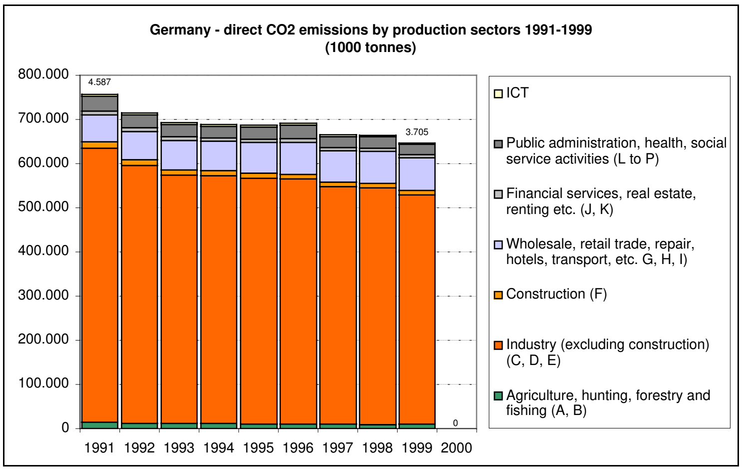


Figure 3-4: Direct CO2-emissions by main production sectors – Germany 1991-2000

Source: Federal Statistical Office Germany 2002

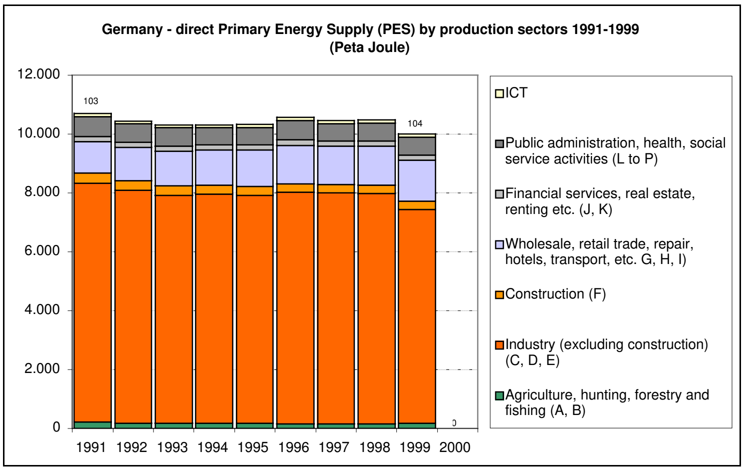


Figure 3-5: Direct primary energy use by main production sectors – Germany 1991-2000

Source: Federal Statistical Office Germany 2002

The ICT sector does not play an important role with regards to direct CO2-emissions and direct energy use. Only 0.6 per cent of overall CO2-emissions are emitted by the ICT sector and about one per cent of overall direct energy use is required by the ICT sector. Accordingly, the ICT sector did not contribute much to the reduction of direct CO2-emissions and energy use.

However, the picture changes if the cumulated CO_2-emissions and energy use (Table 3-3)are also considered. The cumulated figures include in addition the indirect requirements created by intermediate consumption (domestic and foreign), i.e. the cumulated figures consider life-cycle-wide CO_2-emissions and energy use necessary to produce the intermediate goods (including imports) that the ICT sector needs to produce its own goods.

Cumulated CO_2-emissions from the ICT sector are 7-8 times higher than direct CO_2-emissions. In contrast to direct emissions, cumulated CO_2-emissions increased between 1991 and 1999 by more than eight per cent. Therefore, the ICT sector's share of the total cumulated CO_2-emissions increased from 1.7 to 2.2 per cent

The cumulated energy use is about 4-5 times higher than the direct energy use by the ICT sector. It also rose throughout the 1990s by more than 20 per cent. The ICT sector's share of the total cumulated primary energy use also increased from 1.8 per cent to almost 2.4 per cent.

Table 3-3: Direct and cumulated CO_2-emissions and primary energy use by the ICT sector – Germany 1991-1999

	absolute (1000 t)		change (%)	% share on total*	
	1991	**1999**	**'91-'99**	**1991**	**1999**
direct CO_2-emissions	4.587	3.705	-19,2%	0,61%	0,57%
cumulated** CO_2-emissions	26.762	28.985	8,3%	1,72%	2,23%
	absolute (PJ)		change (%)	% share on total	
	1991	**1999**	**'91-'99**	**1991**	**1999**
direct energy use	103	104	1,1%	0,96%	1,04%
cumulated** energy use	415	501	20,8%	1,84%	2,35%

* total refers to production sectors, not including private households

** indirect CO_2-emissions and energy-use induced by domestic and foreign intermediate consumption

Source: Federal Statistical Office Germany 2001

In general, resource productivity expresses the value added generated per unit of environmental pressure variable – in our study direct and cumulated CO_2 and energy use (see Table 3-4).

In 1999, resource productivity in terms of value added per unit direct CO_2-emissions (direct CO_2-productivity) was around 13 times higher for the ICT sector than for the total economy. In 1991, it was only 8 times higher. Throughout the 1990s, the ICT sector significantly increased its resource productivity by almost 100 per cent.

Direct energy productivity of the ICT sector was also significantly higher than that of the total economy (factor 5 to 7). It grew less pronounced than the direct CO_2-productivity by almost 60 per cent between 1991 and 1999.

Again, the picture changes when considering cumulated environmental pressure variables, i.e. looking at the life-cycle-wide environmental pressure created by the ICT sector.

The cumulated CO_2-productivity of the ICT sector was only around 3 times higher than that of the total economy and it grew less than the direct CO_2-productivity by around 50 per cent during the 1990s.

The cumulated energy productivity of the ICT sector was about 3 times higher than that of the total economy and grew by about 32 per cent throughout the 1990s.

Table 3-4: Resource productivities based on 4 environmental pressure variables – ICT and total economy, Germany 1991-1999.

	ICT sector		change (%)	total economy*		change (%)
	1991	1999	'91-'99	1991	1999	'91-'99
direct CO_2-emission productivity (1000 Euro per tonne CO_2)	17.133	33.929	98,0%	2.037	2.667	31,0%
cumulated** CO_2-emission productivity (1000 Euro per tonne CO_2)	2.937	4.337	47,7%	990	1.331	34,4%
direct energy productivity (1000 Euro per Peta Joule energy)	764.746	1.209.450	58,2%	144.030	172.677	19,9%
cumulared** energy productivity (1000 Euro per Peta Joule energy)	189.458	250.841	32,4%	68.345	81.111	18,7%

* total refers to production sectors, not including private households
** considering indirect CO_2-emissions and energy-use induced by domestic and foreign intermediate consumption
Source: Federal Statistical Office Germany 2001 and 2002

3.2.5 Main findings

The ICT sector's macro-economic role in terms of contribution to GDP is about 7-8 per cent and on the increase. The ICT sector shows extraordinarily high labour productivity which doubled over the 1990s. As a consequence, less people were engaged in the ICT sector at the end of the decade than at the beginning (average annual decrease in employment is -2.9 per cent). Clearly, the ICT sector could not compensate for "job losses" in the traditional industry sectors.

The ICT sector's contribution to direct CO_2-emissions and energy use are almost negligible (one per cent or less). However, if one considers in addition the life-cycle-wide indirect environmental pressures, its contribution to cumulated CO_2-emissions and energy use becomes more significant with slightly more than two per cent – which is still clearly below its contribution to total GDP.

The ICT sector's resource productivity (as measured by several ratios) is clearly higher than the resource productivity of the total economy – for direct as well as cumulated environmental pressures, i.e. the ICT sector is significantly "cleaner" per unit value added generated.

3.3 The ICT sector's direct contribution to overall decoupling – decomposition analyses

The following decomposition analyses will explain in a quantitative way the extent to which the ICT sector contributed to the overall decoupling of CO_2-emissions and energy use and economic growth. In particular, it will investigate whether an economic structural change towards an ***e***-economy, i.e. ICT sector's share of total GDP rising, had a significant effect on the overall decoupling.

The methodology[11] allows us to decompose the development of CO_2-emissions and energy into distinct components and to distinguish the following effects:

- *Technology effect*: quantifies CO_2-emissions/energy saved due to technical progress in the form of improved eco-efficiency (i.e. CO_2 or energy per unit value added);

- *Structural change effect*: quantifies CO_2-emissions/energy saved (or induced) by the economic structural change (e.g. a shrinking of energy intensive sectors on the account of service sectors);

[11] A detailed introduction to the methodology of decomposition analyses is given in the interim report.

- *Growth effect*: quantifies CO_2-emissions/energy induced additionally due to overall economic growth.

3.3.1 CO_2-emissions

Table 3-5 shows the results of the decomposition analysis of direct CO_2-emissions in Germany between 1991 and 1999. The first row shows the results for all production sectors[12] which at the same time constitutes the sum of the column beneath.

The absolute reduction of CO_2-emissions by almost 110 million tonnes is due to three overlapping effects. The *technology effect*, i.e. the improved eco-efficiency (direct CO_2-emission productivity), would have led *ceteris paribus*[13] to a decrease by 202 million tonnes if no economic growth and structural change had occurred. On the other hand, without any technological improvement in eco-efficiency and no economic structural change, CO_2-emissions would have increased by around 81 million tonnes due to the overall economic growth (*growth effect*). The structural change effect, i.e. the changed sectoral composition of the economy, would have led *ceteris paribus* to an increase by 13 million tonnes CO_2-emissions. The latter is particularly surprising – it shows that no structural change in favour of new and clean sectors contributed to the decoupling. In summary, the absolute decoupling of CO_2-emissions from economic growth can only be attributed to the intra-sectoral technological improvement in terms of improved eco-efficiency within the sectors.

The last row shows result for the ICT sector. In 1999, the ICT sector emitted 0.9 million tonnes less CO_2. The *technology-effect* was mainly responsible for this reduction. Assuming that the ICT sector's share of the total economy did not grow or lead to increased value added, CO_2-emissions in this sector would have been 2.9 million tonnes less than in 1991 due to technological improvements (increased value added per unit direct CO_2-emission). The positive *structural change effect* tells us that the value added share of the ICT sector increased and that due to this extension an additional 1.6 million tonnes of CO_2 would have been emitted if no technology effect had exited.

[12] Total economy excluding private households.

[13] = other things equal (changing only one target variable whilst keeping all other variables/determinants equal).

Table 3-5: Direct CO_2-emissions – decomposition results, Germany 1991-1999

		(Δx) =	(Δa) μb μc +	μa (Δb) μc +	μa μb (Δc) +	*e*
	direct CO_2-emissions (1000 tonnes)	Δ CO_2 1991-1999	technology effect	structural change effect	growth effect	residual
	total production sectors (without private households)	-109.420	-202.449	12.895	80.818	-663
(A, B)	Agriculture, hunting, forestry and fishing	-5.200	-7.020	410	1.420	-10
(C, D, E)	Total industry (excluding construction)	-101.372	-168.255	1.843	65.535	-474
(F)	Construction	-4.730	-4.557	-1.635	1.446	17
(G, H, I)	Wholesale, retail trade, repair, hotels, transport, etc.	14.207	-3.991	10.555	7.775	-131
(J, K)	Financial services, real estate, renting etc.	-732	-3.352	1.764	885	-29
(L to P)	Public administration, health, social service activities	-10.711	-12.916	-1.043	3.261	-13
	ICT	-882	-2.357	1.001	496	-22

3.3.2 Energy use

The figure below shows the results of the decomposition analysis of direct energy use in Germany 1991-1999. Again, the first row shows the reduction in absolute energy use for all production sectors (-703 PJ) and the relative importance of the different effects. The *technology effect* was the main driver of the absolute overall reduction in primary energy use with -1800 PJ. This implies that without economic growth and structural change, the intra-sectoral technical improvements in energy efficiency would have led to a decrease by 1800 PJ. The growth effect of course *ceteris paribus* would have increased energy use by 1194 PJ. The slightly negative *structural change effect* (-81 PJ) indicates that the changed sectoral composition of the German economy favoured less energy intensive sectors (*vice versa*: energy intensive sectors lost weight in terms of their value added contribution to the entire economy).

The ICT sector did not influence the overall decoupling. The growth of the ICT sector was compensated by improved energy efficiency within this sector.

Table 3-6: Direct energy use – decomposition results, Germany 1991-1999

		(Δx) =	(Δa) μb μc +	μa (Δb) μc +	μa μb (Δc) +	*e*
	direct energy use (PJ)	Δ_energy 1991-1999	technology effect	structural change effect	growth effect	residual
	total production sectors (without private households)	-703	-1.800	-81	1.194	-15
(A, B)	Agriculture, hunting, forestry and fishing	-48	-75	6	21	0
(C, D, E)	Total industry (excluding construction)	-840	-1.457	-261	890	-12
(F)	Construction	-56	-51	-40	35	0
(G, H, I)	Wholesale, retail trade, repair, hotels, transport, etc.	298	-5	164	142	-3
(J, K)	Financial services, real estate, renting etc.	19	-42	41	20	0
(L to P)	Public administration, health, social service activities	-78	-135	-16	73	0
	ICT	1	-35	24	12	0

3.3.3 Main findings

The decomposition analyses reveal two main findings.

For Germany, a significant economic structural change towards a "dematerialised" ***e***-economy caused by the ICT sector having an increased role cannot be observed.

Accordingly, the absolute reduction of CO_2-emissions and energy use, which occurred during the 1990s, can also not be attributed to an economic structural change. The absolute reduction in environmental pressure is attributable to intra-sectoral eco-efficiency improvements in "old" sectors, namely

- manufacture of chemicals and chemical products;
- manufacture of basic metals;
- electricity, gas, steam and hot water supply;
- public administration and defence; compulsory social security.

The macro-economic analysis tools applied could not identify a significant direct role of ICT in the overall decoupling. However, it might have played an indirect role in contributing to technical developments (eco-efficiency improvements) in the "old" economy.

3.3.4 Indirect effects – the role of ICT for the technical development in the "old" industries

So far, macro-economic analyses conclude that the ICT sector did not have a significant direct effect on the overall reduction of CO_2-emissions and energy use in Germany. However, some evidence suggests that ICT indirectly contributes to eco-efficiency improvement s in traditional sectors. The following general indirect effects are referred to in relevant literature[14]:

- intelligent energy management;
- efficient transport systems (logistics);
- substitution of transport;
- dematerialisation;
- ecommerce.

In order to investigate the extent to which the ICT sector might have indirectly influenced eco-efficiency improvements in traditional industries, the following

---

[14] e.g. GeSI. (2002). *Sector report for the Johannesburg Summit 2002 – Information and communications technology.* (Online) Available: http://www.uneptie.org/outreach/wssd/sectors/ICT/ict.htm (2002,07,15)., Cohen, N., (2001). *The Environmental Impact of E-Commerce*, In: Hilty, L. M., Gilgen, P. W., (Eds.), (2001). Sustainability in the Information Society, Metropolis-Verlag, Marburg, pp. 41-52., Jantzen, J., (2001). *Information technology and potential positive environmental effects there of in processing industries*, In: Hilty, L. M., Gilgen, P. W. (Eds.), (2001) Sustainability in the Information Society, Metropolis-Verlag, Marburg, pp. 99-106., Spreng, D., (2001). *Does IT have boundless influences on energy consumption?,* In: Hilty, L. M., Gilgen, P. W. (Eds.), (2001) Sustainability in the Information Society, Metropolis-Verlag, Marburg, pp. 81-90.

research questions and approaches were followed in the second phase of the project:

- The first approach was to find statistical information in order to determine the extent of ICT investment in traditional sectors. Unfortunately, it turned out there is no data available showing ICT investment by single economic production sectors. Only aggregated ICT investment for the total economy was available. For Germany, for instance, overall investment (fixed capital formation) in ICT is increasing. Final demand for ICT goods and services for fixed capital formation (machinery and equipment) increased from 40 billion Euro in 1991 to 60 billion Euro in 2000. Therefore, ICT goods and services increased their share of fixed capital formation (machinery and equipment) from 25 to 31 per cent. However, this general trend does not allow any conclusions to be drawn with regard to the specific sectors which have made the most significant contributions to overall decoupling (i.e. chemicals, basic metals, electricity, etc.).

- The second approach was to have a closer look at the intermediate consumption[15] of "old" sectors using Input-Output tables. If the intermediate use/consumption of ICT goods and services increased in those "old" sectors which contributed most to reductions in CO_2-emissions and energy use, it would be possible to conclude that ICT goods and services were used in order to improve eco-efficiency.

Table 3-7 shows the intermediate consumption of ICT goods and services in three selected "old" sectors for Germany in 1991 and 2000. The three sectors are those which were responsible for the bulk of reductions in CO_2-emissions and energy use.

In general, ICT goods and services form only a minor part of intermediate consumption in those three sectors. In the basic metals industry intermediate consumption of ICT goods and services only accounted for 1.3 per cent in 1991 – it slightly increased to 1.6 per cent of overall intermediate consumption in this sector. In the chemicals sector intermediate consumption of ICT goods and services was slightly higher with about 2.6 per cent but did not increase between 1991 and 2000. Finally, the electricity sector showed the highest share of intermediate consumption of ICT goods and services (3.7). But again, the electricity sector did not increase its relative intermediate consumption of ICT goods and services.

[15] In contrast to investments, intermediate consumption comprises only the purchase of non-durable goods and services and for instance no durable machinery equipment.

Table 3-7: Intermediate use of ICT goods and services by selected sectors – Germany 1991-2000 (source: Federal Statistical Office 2002)

1991			
…in	Manufacture of chemicals and chemical products	Manufacture of basic metals	Electricity, gas, steam and hot water supply
intermediate consumption of…		*million Euro*	
Manufacture of office machinery and computers	137	28	58
Manufacture of radio, television and communication equipment and apparatus	-	-	-
Manufacture of medical, precision and optical instruments, watches and clock	412	215	450
Post and telecommunications	568	116	312
Computer and related activities	212	79	109
ICT goods and services (all together)	*1.329*	*438*	*929*
total intermediate consumption	52.072	34.459	25.365
		in % of total intermediate consumption	
Manufacture of office machinery and computers	0,3	0,1	0,2
Manufacture of radio, television and communication equipment and apparatus	-	-	-
Manufacture of medical, precision and optical instruments, watches and clock	0,8	0,6	1,8
Post and telecommunications	1,1	0,3	1,2
Computer and related activities	0,4	0,2	0,4
ICT goods and services (all together)	*2,6*	*1,3*	*3,7*
total intermediate consumption	100,0	100,0	100,0

2000			
…in	Manufacture of chemicals and chemical products	Manufacture of basic metals	Electricity, gas, steam and hot water supply
intermediate consumption of…		*million Euro*	
Manufacture of office machinery and computers	229	127	65
Manufacture of radio, television and communication equipment and apparatus	-	-	2
Manufacture of medical, precision and optical instruments, watches and clock	326	132	196
Post and telecommunications	851	232	282
Computer and related activities	545	155	191
ICT goods and services (all together)	*1.951*	*646*	*736*
total intermediate consumption	72.042	40.760	19.913
		in % of total intermediate consumption	
Manufacture of office machinery and computers	0,3	0,3	0,3
Manufacture of radio, television and communication equipment and apparatus	-	-	0,0
Manufacture of medical, precision and optical instruments, watches and clock	0,5	0,3	1,0
Post and telecommunications	1,2	0,6	1,4
Computer and related activities	0,8	0,4	1,0
ICT goods and services (all together)	*2,7*	*1,6*	*3,7*
total intermediate consumption	100,0	100,0	100,0

3.3.5 Main findings:

Macro-economic statistics are seldom available and macro-economic analysis tools are limited to investigating possible “indirect” effects of ICT on the eco-efficiency performance of “old” sectors responsible for overall decoupling (chemicals, basic metals, electricity).

Based on Input-Output tables for the German economy 1991-2000, the analysis of the intermediate demand for ICT goods and services within these “old” sectors does not suggest that there is a provable link between ICT and improved eco-efficiency performance.

3.4 Conclusions of macro-economic analyses

In summary, the macro-economic analyses suggest that the structural change slowly taking place towards an *e*-economy neither constitutes the “big bang” solution favouring a dematerialised society nor a big threat from an environmental point of view. So far, no dramatic negative environmental effects caused by a structural change towards an ***e***-economy seems likely, though the availability of adequate statistics needs improvement. From a macro-economic perspective, a policy framework aimed at facilitating this structural change (Lisbon Strategy) should carefully monitor the macro-economic technology pattern in the form of labour, resource and capital productivities in order to avoid unwanted developments like for instance the decrease in employment in the ICT sector.

1. CO_2-emissions and energy use per unit gross value added generated is comparably low in the ICT sector.

2. The ICT sector's (as it can be defined statistically) contribution to overall value added is moderate, ranging from five to eight per cent. The "old" economy is still significant. An inter-sectoral structural change (in terms of a shift in share of GDP from "old" to "new" sectors) is taking place relatively slowly. Hence, the potential environmental effects of this are difficult to detect.

3. In order to anticipate possible effects of a coming or "desired" structural change, it is recommended to conduct prospective analyses ("*what if*" scenarios) with the help of macro-economic models. In the near future however, the ICT sector will not contribute to an overall structural change that will significantly support a decoupling of CO_2 and energy from economic growth.

4. Within the "old" sectors, some technological development patterns can be measured via the changing allocation of production factors:

   a) Labour productivity and resource productivity have been increasing. For both developments, ICT may have played a role based on some plausible reasoning (but no "hard" statistical facts can be referred to from a macro-economic analytical point of view).

   b) Due to a strong growth in labour productivity within the ICT sector, it was not possible to compensate for "job losses" in the "old" economy; the labour force actually decreased in the ICT sector.

   c) Capital productivity has been decreasing, i.e. the relation between value added and depreciation. This means, less investment in machinery equipment and buildings. However, the share of ICT investments to total investments has increased on the level of the total economy.

5. In the past, the decoupling of certain environmental pressures (CO_2, energy) from economic growth can only be attributed to the "old" sectors (chemicals, basic metals, electricity). The available macro-economic analysis tools cannot identify a significant indirect role of ICT contributing to the technical developments within these "old" sectors. However, it seems likely that ICT has contributed to the improved eco-efficiency of "old" sectors – rather than vice versa.

6. Growth effects overcompensating eco-efficiency improvements in the "old" sectors are not significant (on the macro level). The increase in CO_2-emissions and energy within the ICT sector, if at all, seem negligible. Even if the ICT sector extended its economic significance (increasing share of total GDP), it would not lead to significant environmental effects.

7. Further research could investigate the possible environmental implications of ICT use in private households since this point was not addressed by this macro-economic analysis. Further research should also highlight the "enabling role" of

ICT whereby approaches beyond macro-economic analysis tools will be required towards this end.

8. The availability of adequate date could be improved, in particular combined macro-economic and environmental information systems such as NAMEA or the German Integrated Environmental and Economic Accounts.

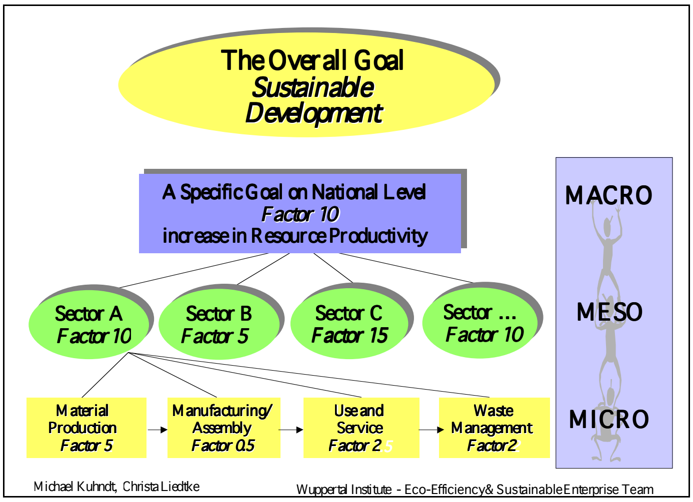
4 Virtual Dematerialisation: ICT application and its dematerialisation potential

4.1 Introduction

Trends and changes observed on the macro level are always the result of (a large number of) activities at the micro level. This micro-macro link for resource efficiency can be illustrated by the example of Factor 10 shown in the box below.

Box 4-1: Factor 10 on different levels.

The Factor 10 concept is used to designate a measure for environmental performance at various levels, as well as on the national policy level, and as a business concept. The Factor 10 concept can be regarded as an approach to focus on dematerialisation concepts by setting quantitative targets for efficiency improvements. The Factor 10 goal refers to total material flows (including also material flows for energy production) within the economy and can be set, for example, in the national policy plan as a quantitative goal.[16] For the industrial production of goods and services within this national economy, this does not mean that the resource productivity of every single process or every individual phase of the life cycle must be drastically increased. Rather, industrial sectors as a whole contribute with different factors to the Factor 10 goal according to their life-cycle-wide potential to reduce resource consumption.



[16] The "Ecocycle" Commission from the Swedish Government is driving for a Factor 10 within the next 25-50 years (Kretsloppsdelegationens Rapport 1997); The Netherlands formulated a Factor 4 goal in their national environmental plan in 1996 (Ministry of Housing, Spatial Planning and the Environment 1996); Austria wrote a Factor 10 goal into their national environmental plan in 1995 (Austrian Government 1995); the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety suggested a 2.5-fold increased raw material productivity by 2020 compared to 1993 and a 2-fold increased energy productivity by 2020 compared to 1990 (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety 1998).

Looking more specifically at ICT applications on the micro level, the associated resource consumption can be classified in primary, secondary or tertiary effects (see table below).

Table 4-1: Categorisation of resource consumption of ICT applications (adopted from Fichter[17] and Berkhout & Hertin[18])

Effect	Caused by	Examples	Aspects
Primary effects	Communication infrastructure	Terminal equipment such as the PC, mobile phones	Infrastructure production and installation Maintenance of infrastructure End-of-life-management
		Net infrastructure	
		Servers, routers etc.	
	Other infrastructure such as building, transport, water, etc.	Roads, train, houses	
		Trucks, trains, vessels	
Secondary effects	Application	Ecommerce - B2B - B2C - C2C	Energy consumption Alteration of existing products and service systems Material consumption for new product and services
		Telework	
		Egovernment - G2B - G2C - G2A	
Tertiary effects	Changes in consumption pattern, new habits, rebound effects	Increase in consumption	Energy consumption Material consumption
		Substitution effects	
		Side effects	

Primary effects refer to the effects caused by ICT infrastructure and equipment, e.g. the material consumption in producing PCs and Internet servers. The reduced need for office space as a result of telework or the increase in just-in-time deliveries thanks to B2B applications are examples of secondary effects. Secondary effects derive from existing desires or habits that are fulfilled through new, ICT-based applications. In contrast, tertiary effects stem from new habits or consumption patterns that arise through the use of ICTs, such as the increase in transatlantic freight shipments as a result of online auctions in the US.

Considering the above table, the dematerialisation potential of ICT applications will depend on different aspects. Chapter 4 will focus on the resource consumption for

[17] Fichter, K., (2001). *Sustainable Business Strategies in the Internet Economy*, In: Loreny, H., Gilgen, P., (Eds.) *Sustainability in the Information Society*, Marburg, 2001, pp. 109-118.

[18] Berkhout, F., Hertin, J., (2001). *Impacts of Information and Communications Technologies on Environmental Sustainability: Speculations and Evidence*, Report to the OECD, Brighton, UK.

ICT infrastructure and on certain types of ICT applications (ecommerce, telework, egovernment). The changes in consumption patterns and rebound effects will be discussed. The discussion is based on the findings derived from the case study research within the Digital Europe project which was conducted in different sectors (ICT, entertainment, transport and financial sector, see also case study reports on mobile computing, digital music and ebanking) as well as from related desk-based research.

4.2 Resource Consumption by Communication Infrastructure

While the environmental effects caused directly by ebusiness applications are categorised as secondary effects (see Table 4-1), it is not possible to ignore the primary environmental effects of the production and use of ICTs, since ebusiness depends on their usage. Different communication infrastructures are available to enable ebusiness activities. Among those, the Internet is currently and in the near future the main communication infrastructure, next to mobile technologies and digital TV. For Germany, the Office of Technology Assessment at the German Parliament stated that the Internet will be the dominant infrastructure for ecommerce by 2010.[19]

The growth of the Internet goes hand in hand with an increase in infrastructure. A study by Intel concluded that in 2001 only four per cent of the servers needed in 2005 are in place.[20] According to a survey by the Internet Software Consortium[21], the number of Internet hosts grew world-wide from 29.67 million at the beginning of 1998 to over 162 million in July 2002, which results in 20 per cent growth every six months (see figure below).

[19] Office of Technology Assessment at the German Parliament (TAB) (2002). *Innovationsbedingungen des Ecommerce – die technischen Kommunicationsinfrastrukturen für den elektronischen Handel*. [Innovation conditions of ecommerce: the technical communication infrastructure for electronic commerce]. Background paper no. 7. TAB.

[20] VDI Nachrichten 30. März 2001, *Netzknoten sind wahre Stromfresser*. [Internet nodes are extreme electricity consumers].

[21] Internet Software Consortium, www.isc.org,

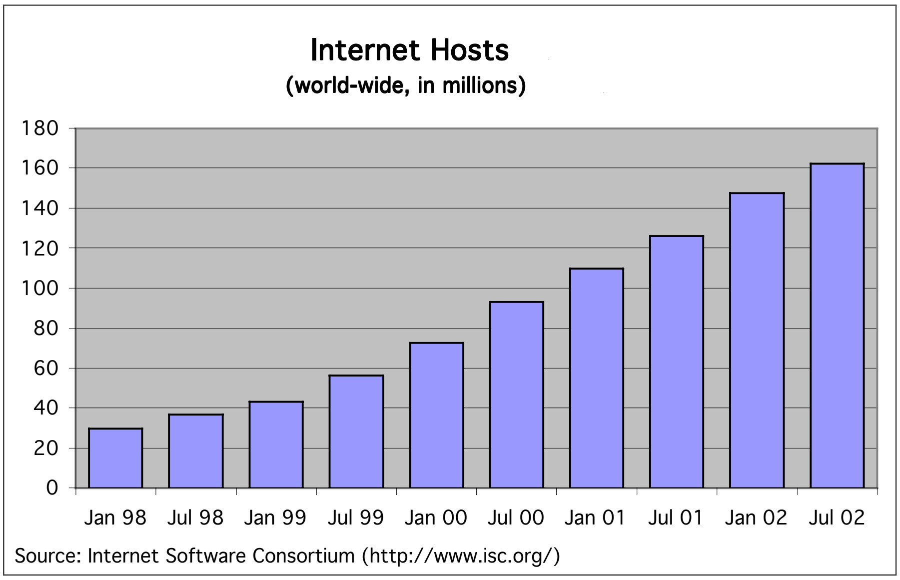


Figure 4-1: Internet hosts world-wide

The number of devices used for the Internet is characteristic for the system's complexity. With regard to the primary effects, the Digital Europe research focused on the technical communication infrastructure and assessed and quantified the dematerialisation potential on a case study level.[22]

The physical infrastructure forming the Internet can, with a certain level of abstraction and simplification, be broken down into four different categories:

Network access devices (client side) are used by clients (users) to access the services provided by Internet service and content providers. Those services are based on files and programmes stored on 'servers'. PCs and laptops account for the overwhelming majority of devices used to access the Internet. A prognosis for the near future sees many more devices such as mobiles, set-top boxes[23], video game systems, fridges and so on as forthcoming connection devices.

Content providing devices: This category basically covers servers. In general, a server is a computer programme that provides services to other programmes on the same or other computers. The computer in which a server programme runs is also frequently referred to as a server, though it may contain a number of servers and other programmes. Specific to the web, a web server is a programme (housed in a computer) that serves HTML[24] pages requested by a web browser at the client's computer. Several other types of servers exist, such as FTP servers, Mail servers and News servers.

---

[22] see Digital Europe case study report on mobile computing.

[23] A set-top box is a box that sits on top of a television set and is the interface between the home television and the cable TV company. New technologies evolving for set-top boxes are Internet access, video-on-demand, video games, educational services, database searches, and home shopping.

[24] HTML (Hypertext Markup Language) is a set of codes inserted in a file intended to display a web page on a browser.

Intermediate devices comprise several different devices that enable communication on the net. 'Routers', 'Switches' or 'Gateways' switch or route traffic on the network – e.g. from a long-distance network to a local exchange point. 'Bridges' connect different networks, 'Repeaters' receive, amplify and retransmit signals and 'Firewalls' are programmes located at network gateways or servers that protect the resources from other users and programmes.[25]

Data transfer media are the 'highways' (or sometimes just 'country lanes') that transfer the data. Most common are 'cables', traditionally made of copper; the newer and much faster ones are made of optic fibre. They range from old-style telephone networks with transfer rates up to 56,000 bps to intercontinental 'backbones' with a bandwidth above 1 GBps. A backbone is a larger transmission line that carries data gathered from lines that interconnect with it. The Internet is a wide area network (WAN) comprised of a number of backbones – regional networks that carry long-distance traffic. At a local level a backbone is a line or a set of lines that connects local area networks (LANs) to a WAN. On a national level, directional radio is used as well.

In the use phase all infrastructure parts are associated with energy demand, which is an important factor for accounting the resource consumption of the Internet. Desk-based research by the Wuppertal Institute and other researchers on the electricity consumption of Internet infrastructure highlights the following:

- The Internet's electricity consumption is quite considerable, especially if the entire life cycle is considered. For example in Germany, the life-cycle electricity consumption of the entire Internet infrastructure is estimated to account for three to four per cent of national consumption, whereas the use phase only accounts for 1.3 per cent.[26]

- The future energy demand by the Internet is most likely to increase. Initial estimates of future energy consumption point out that the electricity demand from the Internet in Germany could increase to five per cent of total electricity consumption by 2010[27]. Also, research conducted by Romm in the US and by Aebischer and Huser in Switzerland point to an increase in the

[25] Until the mid-90s all national Internet traffic in Germany was routed via the US. In 1995 the 'Deutscher Commercial Internet Exchange' (DE-CIX) started operating and presently connects all but one major national and many international ISPs. 85% of German and 35% of European Internet traffic is routed over the DE-CIX. The advantage of such a centralised peering point is that traffic within Germany is routed within the country, leading to much faster and less costly data exchange (Deutscher Commercial Internet Exchange, 2001).

[26] Türk, V., Kuhndt, M. (2002). *The Resource Intensity of the Internet Infrastructure*. Wuppertal Paper, in preparation.

[27] Thomas, S. (2002). *www.internet.co2? GHG emissions of the Internet in Germany*. Presentation at the IEA Workshop: Information and Communication Technology: the Next Challenge for Energy Systems? 21/22 February 2002, Paris. Information is based on unpublished results by Stephan Thomas and Dr. Claus Barthel, Wuppertal Institute.

demand for energy caused by the entire Internet infrastructure, despite the energy efficiency improvements of individual Internet-enabled activities.[28,29]

The associated resource consumption based on energy consumption in the use phase of the Internet depends – as shown by previous research by the Wuppertal Institute[30] – on how the electricity is produced. The resource consumption itself relies to a large extent on the energy grid of the specific country under investigation. In Germany, the material flows connected to electricity consumption during the use phase account currently for about 0.5per cent of nation-wide material consumption[31]. However, with increasing electricity demand by the Internet, the related resource consumption is most likely to rise.

Focusing on electricity and its resource base in the use phase only – as an indicator to evaluate the significance of resource flows caused by the Internet infrastructure – is problematic as it is just one part of the overall life-cycle picture, as illustrated in the following figure.

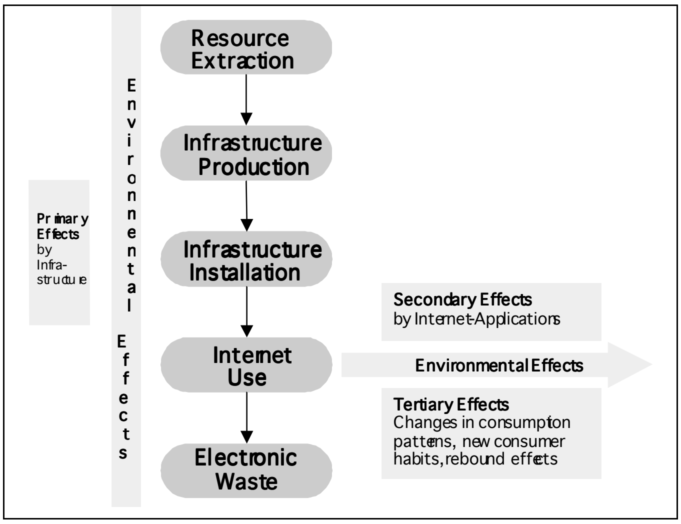


Figure 4-2: Life cycle of the Internet infrastructure (Source: Wuppertal Institute).

Resource consumption over the total life span has to reflect the raw material extraction, production of components, manufacturing, installation and end-of-life phase of the equipment. Taking into account the entire life cycle of the infrastructure

[28] Romm, J. (1999) *The Internet Economy and Global Warming,* The Centre for Energy and Climate Solutions.

[29] Aebischer, B., Huser, A. (2000). *Vernetzung im Haushalt, Auswirkungen auf den Stromverbrauch.* [Internet in the household: effects on the electricity consumption]. Zürich/Bern.

[30] E.g. by Liedtke, C., Rohn, H., Kuhndt M., Nickel, R. (1998). *Applying Material Flow Accounting: Eco-Auditing and Resource Management at the Kambium Furniture Workshop*. Journal of Industrial Ecology, Volume 2, Number 3, MIT Press; or: Manstein, Ch. (1996). *Das Elektrizitätsmodul im MIPS-Konzept* [Electricity module for the MIPS concept]. Wuppertal Papers, No. 51, Wuppertal Institute for Climate, Environment, Energy, Wuppertal, Germany.

[31] Türk, V., Kuhndt, M. (2002). *The Resource Intensity of the Internet Infrastructure*. Wuppertal Paper, in preparation.

will likely increase the share considerably, due to the resource-intense levels of processing in the upstream processes. A first and very rough estimate by the Wuppertal Institute on the material intensity necessary for producing just the servers came to about 0.2 kg abiotic raw materials per hour of Internet use. While this figure can't be more than just a first hint, it might serve as an indication of the volume of resource flows still to be included if all the infrastructure was considered.

While studies attempting to quantify the material intensity required to produce or dispose of the appliances used in the entire Internet system are not known, case study research within Digital Europe highlighted specific aspects of the communication infrastructure. Regarding the resource consumption for the end appliances**,** the following findings can be drawn:

- The **production of end appliances** accounts for a high proportion of the entire product's resource consumption. Within the case study[32] for the notebook, the production induced almost the same quantity of resources as the use phase (40 to 50per cent, depending on user behaviour). This is a result of the components' material content with intensive upstream processing demands for components such as PWBs, LCDs, chips and precious metals. This hypothesis is also supported by the results of the cumulated energy demands of the ICT sector on the macro-economic level (see chapter 2). Most of the materials used arise from non-renewable sources. Further, it must be assumed that the share of recycled and reused raw materials in end appliances is low. The case study on mobile computing highlighted that the use of secondary materials is an opportunity for resource efficiencies.
- The comparative analysis of different end appliances (the case study analysed a handheld, a notebook and a traditional personal organiser) shows that the products differ in their resource consumption. However, the efficiency gains from a shift to lighter (dematerialised) products are not proportional to the difference in weight. The handheld weighs only 200 grams (seven per cent of the notebook's weight) but its production consumes 81 kg of abiotic raw materials (19 per cent of the notebook's backpack). This relatively high resource consumption is a result of a high share of functional materials in the smaller end appliances and additional items such as the external modem.
- There are differences in the comfort and handling of information processing with different end appliances. There can be "mobility-related" advantages for smaller products or "processing capability-related" advantages for the fixed and larger equipment. As the users of computing devices do not need (and cannot use) the services offered by mobile equipment at one time, the **concept of a shared use of electronic equipment** is coming into the picture as an improvement option. The shared use of notebooks and individual use of handheld devices can increase overall efficiency as shown in the scenario. However, as most of the handhelds are currently used in combination with notebooks, the handheld today is more of an add-on device than a substitution for the notebook. As long as consumers demand a notebook or a PC in addition to the handheld substitution, an increase in resource efficiency will not take place.
- The **electricity consumption** of the end appliances in the use phase contributes significantly to the backpack of the infrastructure. The electricity consumption is determined by the use characteristics of the end appliances

[32] see also Digital Europe case study report on the environmental impacts of mobile computing.

(time in active, standby and sleep modus), the charging efficiency as well as the standby power drawn by the charger. The energy source (e.g. coal, oil, hydro, wind) and the technology used determine the material backpack of the handheld. Based on a European electricity mix and on specific assumptions regarding consumer behaviour, the use phase's contribution to the overall abiotic material intensity varies between 22 and 32 per cent.

- **Transportation** from ICT manufacturing to the consumer contributes little to the entire resource consumption within the device's life cycle. In the case study for the handheld it accounted for less than one per cent of the abiotic raw materials. However, if the transport of components and subcomponents before assembly, possibly by air, were to be considered, transport's contribution to resource consumption would probably be higher. Also, consumer habits heavily influence the transport intensity.
- Considering the great efforts gone to to produce single end appliances, **reuse and recycling** as well as the **extension of the use phase** are important improvement options from a life-cycle perspective. However, the actual number of recycled devices is expected to be low. A good motivation for the end-user to return products and efficient logistics (take back and recycling) are the basis of an efficient recycling scheme. Therefore, it must be considered that miniaturisation leads to difficulties regarding their end-of-life management. As the material value of smaller products is reduced and the smaller size of the device allows them to be discarded with household waste, then the take back and recycling systems face major challenges. It is not yet clear how great an impact the WEEE directive will have on this matter. A scenario, conducted in the case study to evaluate an increased share of secondary materials, points out some improvement areas. The proposed directive on establishing a framework for Eco-design of End Use Equipment might also improve the conditions for enhanced design. However, for reliable evaluation of recycling schemes more practical data and research is needed.

In summary, it seems that with the growth of the Internet's infrastructure comes a seemingly inevitable increase in the resource consumption for the production of electronic equipment and its electricity consumption. In addition, the number of mobile information processing devices with Internet access is increasing, which can potentially lead to additional rebound effects, e.g. through an increase in accepted travel and commuting distances. Thus, for the planning of the Internet's future development the related resource consumption should be considered, especially as there already seems to be an overcapacity for parts of the European Internet, e.g. for data transfer media.[33]

4.3 Resource Consumption by Ecommerce

The growth of ICT infrastructure is based on the (expected) expansion of demands for different ICT applications, ecommerce being one of them. A discussion of the effects of ecommerce on resource consumption requires a clarification of the meaning of the term "ecommerce". The term ecommerce is often used with different meanings, depending on the individual's job function, professional orientation and background, focal product or service, as well as type of information technology deployed. For example, one may identify different communication technologies that

[33] Der Spiegel (2002). *Internet: Der Rest der Finsternis.* [Internet: the rest of the darkness]. 24, 2002. p.188.

individually or mutually enable electronic commerce (see section above). Electronic commerce covers more than the mere use of communication technologies. Ecommerce involves much the same processes as selling goods and services offline. Considering the scope of this study – the identification of linkages between ecommerce and its “real world” implications on resource efficiency – an ecommerce definition referring to physical goods and services will be used. In this sense, ecommerce can simply be understood as the buying and selling of goods and services on the Internet. The process of economic transactions can be divided in the information phase, including product information, bids and contracting, the production and delivery phase as well as the payment phase, as illustrated in the following figure.

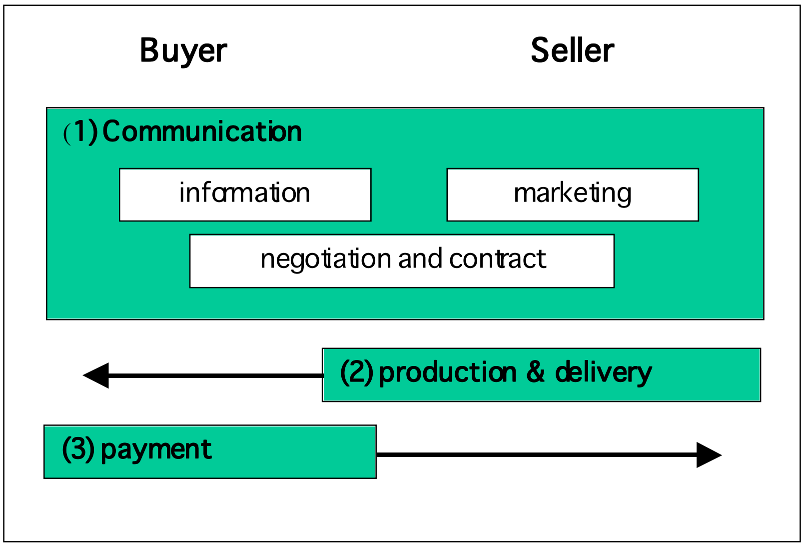


Figure 4-3: Phases of commerce (Source Wuppertal Institute).

Depending on the degree of electronic support in each phase, different options of ecommerce can be distinguished as illustrated in the following figure:

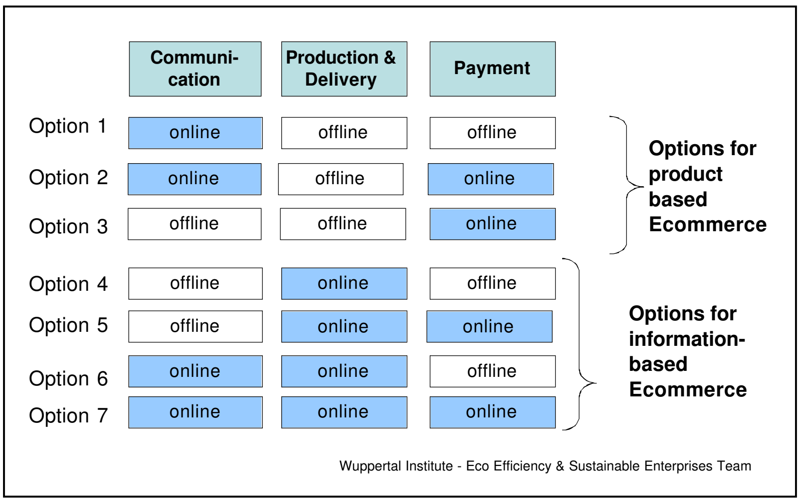


Figure 4-4: Degree of electronic penetration of ecommerce (Source Wuppertal Institute).

In the communication phase the buyer and the seller exchange information about the product or service, including negotiation and contracting. From the seller's perspective it includes mainly the marketing activities. From the buyer's perspective this phase includes the preparation of the purchasing decision by the collection and compilation of information material, e.g. visiting the shop to gather information. The payment phase is similar to the communication phase related to an exchange of (monetary) information. The type of information material, its amount and the means of distribution will determine the resource consumption of both the communication and payment phases. Regarding production and delivery, different options are possible, i.e. the product or service can be produced and delivered online or offline. However, the online option is only possible for informational products. These aspects will be analysed regarding the implications for resource consumption in more detail below.

In economic transactions, the role of the actors (buyer or seller) and the type of actors (government, business, consumer) are aspects which need to be considered when elaborating on the resource efficiency of ecommerce. The reason for this is that the resource intensity of ecommerce and the potential ways it can be reduced is influenced by the role and type of the actor. The following sections cover the economically most important forms of ecommerce (B2C and B2B)[34] and discuss their resource intensity. In addition, egovernment (G2G, G2C and G2B) will be looked at due to its rapid expansion. For the section on B2C ecommerce, research is based on case studies, while the sections on B2B and egovernment are primarily based on desk-top research. In all cases findings have been adjusted according to insights gained in the other sections.

4.3.1 Resource consumption by B2C ecommerce

For analysing the environmental effects of B2C ecommerce, findings from the case study research within Digital Europe are utilised. Focusing on resource efficiency and considering in particular the digital music and online-banking cases, the analysis focuses on the communication- and payment-, as well as production- and delivery phase.

4.3.1.1 Communication and payment phase

Table 4.1 introduced the different effects characteristic to almost all ICT applications. Communication and payment within B2C ecommerce transactions are no exception in this respect. Effects on the resource efficiency resulting directly from communication/payment stem from the usage of ICT equipment and are described in detail in chapter 4.2.

The use of ICTs for communication by the consumer makes shopping related activities such as information gathering, negotiation and contracting more rapid, transparent and economically efficient. An increasing (economic) efficiency might lead to resource savings. But like most other efficiency gains, they might lead to rebound effects as well, as discussed further down in this section.

[34] Eames, M. et al. (2000). E-topia? Contextual Scenarios for Digital Futures. SPRU-Science and Technology Policy Research, University of Sussex.

The effects of digital payments have been evaluated in detail in the online banking case study. Paying a bill online is in a way nothing but a special type of information-based ecommerce, which is discussed in detail in the following chapter. Condensed to a few highlights, one of the most important findings for online banking is that it is responsible for significant consumption of resources. On the banking side, clearly energy consumption followed by the building infrastructure dominate, while for the consumer it is the material flows connected to the ICT devices. The case study finds the material flows caused by one online bill payment to be at the same level as those required to produce four beverage cans. Electronic payment is not only connected to resource consumption, but might also reduce the costs of products or services.

But, as indicated above, the tertiary effects, i.e. rebound and side effects, are quite likely to influence the final outcome. Connected to the gain in time efficiency and transparency is a saving of time. The effects of freed time are diverse and difficult to assess, and activities on which the consumer will use the time saved are not predictable, but an increase in (resource intense) leisure activities, such as travel, is a likely option. Here policies need quickly to adjust the framework conditions as in the absence of countermeasures the resource consumption is likely to increase.

Price reductions through the use of electronic payments and an increased price transparency increase the bargaining power of the consumer and lead to lower prices. The effect on resource consumption depends on how consumers choose to spend the saved money. Possibly, people will consume more goods, leading to additional material flows. This leads to the conclusion, similar to the effects from the communication phase, that countermeasures are needed to promote more resource efficient consumption patterns.

Another trend combining efficiency and transparency gains is the increasing empowerment of consumers. Shoppers are increasingly able to choose between a large number of suppliers, compare prices and specify requirements. Buyers' clubs emerge, aggregating demand for the benefit of consumers. Consequences are reductions in prices and therefore a chance for additional consumption. But chances exist that consumers will also use the possibilities to include additional criteria in the decision process. A credible and convenient one-stop web-platform, offering an array of information about environmental, social, ethical and other criteria of products and producers, is very likely to help raise the demand for more sustainable products.

4.3.1.2 Production and delivery phase

Regarding the production and delivery phase, the case studies as well as desktop research indicate that the **object of the economic transaction** (the product or service) is a decisive factor for the overall material intensity. The material intensity of the transaction's object as such determines substantially the influence that ecommerce has on resource efficiency. For that reason production of products, if applicable, is taken into the equation as well. Ecommerce activities can therefore be divided between product-based ecommerce and information-based ecommerce, depending on the degree of physical material used to provide the service associated with the transaction object.[35]

But ecommerce contributes only with a small share to the customers supply with goods, though the growth rates are significant.[36] Reasons for that are manifold, partly based on the fact that not all items are equally suitable for ecommerce. Characteristics of the products and the consumers attitude towards them are of core importance for a product's "ecommerce qualification". Generally speaking, the following elements support the affinity to ecommerce:

- The product is standardised in shape and quality.
- The product is not perishable within a short period of time.
- The customer normally does not need explanations or advice by a sales person.
- The customer normally does not need an explicit tryout of the look-and-feel before the purchase.

As a result, the sales concentrate on certain product groups, as the following table shows[37].

[35] This approach is in accordance with the classification of services, e.g. by White et al. (1999). Servicing: A quiet transition to extended producer responsibility, In: Mont, O. (1999). Product service systems. IIIEE, Lund University.

[36] Figures given in the Literature often deal with the value of goods purchased, which of course is not very relevant from a transport perspective, in particular if in some cases the impressive totals are dominated by financial transactions. The latter group of e-services definitively should be grouped separately, bearing in mind, that special travel for conducting financial transactions is of no particular importance within the distances travelled privately.

[37] Vogt, Walter, Glaser, Walter et. al. (2002): Verkehrliche Auswirkungen von Teleshopping und Telecommerce auf die Mobilität privater Haushalte (transport effects of teleshopping and telecommerce on the mobility of private households), Stuttgart 2002, Universität Stuttgart, Veröffentlichungen aus dem Institut für Straßen- und Verkehrswesen (University Stuttgart, publications from the Institute on Roads and Traffic), p. 27.

Table 4-2: B2C shares in sales by product groups, Germany (Gfk 2001, after Vogt, Glaser et.al. (2002), p. 27.)

Product groups	Shares in sales
Books, CD, audio-media	12 %
PC, electric appliances, and parts	19 %
Clothing, shoes	13 %
Toy articles	2 %
Travel, travel tickets	28 %
Events	4 %
Cars, and parts	4 %
Goods for daily supply	3 %
Other	15 %

Just a few segments make up the bulk: travel, together with tickets for events, add up to nearly a third, and electric/electronic goods together with media come up to a similar share. Conversely, goods for daily supply represent only three per cent. As an example of expectations on the future share of B2C, a study of Transport and Logistiek Netherlands is based the on assumption that the consumer will buy 15 per cent of non-food products and 10 per cent of food products through e-shops in 2005 [38]. This estimation appears to be rather optimistic.

Product-based ecommerce draws on a physical product as the mode for delivering services to the customer. An example of product-based ecommerce would be purchasing CDs at an online retailer. Based on the experience of the case studies within Digital Europe, the following aspects characterise product-based ecommerce:

- The physical production and delivery of a product is a basic necessity;
- Among today's most popular B2C ecommerce products are books, CDs, electric appliances etc.; products produced in high volumes for the mass market. For these kinds of product, the production sites' infrastructure contributes to a rather low degree of the overall material intensity.
- Substantial savings compared to traditional retailing (without ecommerce) may occur in two aspects:
    - Infrastructure. For buildings with a rather low turn-over of products, e.g. retailer shops, the building infrastructure turns out to be of importance for the overall material intensity. In the case of the digital music case study, the CD shop scores the second highest material intensity of all aspects considered. Online shopping renders these buildings unnecessary.
    - Transport. Assuming that the consumer's preferred means of transport is private motorised transportation, this turns out to be of importance. The digital music case study finds it to be the third biggest contributor to the material intensity, as does the case study on banking. Other studies on

[38] cf. vVan Leewen, Robert. Transport en Logistiek Netherlands: New Wine in Old Bottles – Argument in Favour of More Space for Road Haulage to Accomodate the Growth of New Economy; paper presented at the Joint OECD/ECMT Seminar "The Impact of E-Commerce on Transport, Paris 5/6 juin 2001.

product-based ecommerce come to similar findings.[39,40,41] Transportation from producer to the retailer, as well as by the parcel service, is less significant, with one reported and unsurprising exception: if ecommerce involves or, even worse, induces air transportation of the product to the retailer.[42] It is important to note that these statements refer to the relative weighing of transportation at a case study level.

- Additional consumption compared to traditional retailing occurs in connection with ICT production and usage. Different studies[43] [44] as well as chapter 4.2 shed some light on the material backpack of ICT's usage and the case study on digital music finds it to be in a similar order of magnitude as the above-mentioned savings in infrastructure and transport.

In the case of product-based ecommerce, the physical production and delivery of a product takes place in a similar way to traditional shopping. Thus, the related resource consumption can be only marginally influenced by ICT, as the production of the product and most of the logistical efforts for delivery remain. For products that don't require a lot of resources in production (e.g. CDs), consumption specific to traditional commerce, such as retail infrastructure and consumer transport, are likely to be balanced or even offset by those specific to online shopping, like those connected to ICT infrastructure. The resource savings due to ecommerce for products that have a high resource intensity during production are small anyway since production will likely dominate the material intensity along the life cycle. Finally, there is an important difference compared to digitised products (see information-based ecommerce): digitised products can be shared by an unlimited number of users if not restricted by any kind of software protection. This means that one "product" can serve many users, adding a functionality that does not exist for traditional products sold by ecommerce.

Information-based ecommerce refers to services that are delivered to the customer via ICT infrastructure. Information is the origin of this type of ecommerce, i.e. they are not based on a physical product which is handed over to the customer. Online banking and online music downloads are popular examples of such digital

---

[39] Swedish EPA*, Home shopping will save energy*, 2000. Available online at: http://www.swedenvironment.environ.se/no0001/0001.html#art13.

[40] Reichling, M. Otto, T. (2002). Environmental Impact of the New Economy, In: Park, J., Roome, N. (Eds.) Ecology of the New Economy, Greenleaf.

[41] Türk, V., Ritthoff, M., Geibler, J. von & Kuhndt, M. (2002). *internet: virtuell = umweltfreundlich?* [internet: virtual = environmentally sound?] In: Altner, G., Mettler-von Meibom, B., Simonis, U. & Weizsäcker, E.U. von (Editors), Jahrbuch Ökologie 2003. Beck, München, p. 110-123.

[42] Hendrickson, C. T., Matthews, H. S., Soh, D. L. (2000). *The Net Effect: Environmental Implications of E-commerce and the Logistics*, Pittsburgh: Carnegie Mellon University, 2000.

[43] Barthel, Claus, Lechtenböhmer, Stefan & Thomas, Stefan. (2001). *GHG Emission Trends of the Internet in Germany*. In Langrock, Thomas, Ott, Hermann E. & Takeuchi, Tsuneo. (2001) *International Climate Policy & the IT-Secto*r (55-70). Wuppertal, Wuppertal Spezial 19, Wuppertal Institute.

[44] Türk, Volker. (2001). *Assessing the Resource Intensity of the Internet Infrastructure: Data Analysis for a Material-Flow Oriented Approach and First Results on Electricity Consumption*. M. Sc. thesis at the Lund University, Sweden. [Online]. Available: http://www.iiiee.lu.se/ [2002, July 17].

services.[45] Information-based ecommerce and its influence on resource consumption, drawn from the Digital Europe case studies, is characterised by the following key points:

- Contrary to what one might expect, information-based ecommerce is not just virtual, but is very much rooted in the material world. As well as traditional shopping or product-based ecommerce, it has a significant environmental load.
    - One key influencing factor is the material intensity of ICT equipment and Internet usage. Both, the resources required for the power supply as well as those needed to produce the devices are significant. A decisive aspect is the online time, given that current research indicates a power consumption of about 500 W per hour of Internet use. For comparison, a PC including a CRT[46] monitor is estimated to consume about 100 W.
    - However, for services that need large back-offices, such as banking, the building infrastructure might be even more important than the ICT equipment. In the case studies, the energy consumption of the building infrastructure is particularly significant.
- Purely digital distribution of information, whether "products" delivered as files (e.g. music files instead of CDs) or services (e.g. online banking), is visibly less material intense than traditional commerce. Clearly, information-based ecommerce has the potential to decouple economic growth from resource consumption, since the product as such, as well as parts of the infrastructure, can become obsolete. Savings can be realised at:
    - Product: Making only a small product such as a CD obsolete helps to reduce the resource consumption associated with the service it provides.
    - Production and retail infrastructure: The case study on product-based ecommerce highlighted the potentially high contribution to the total material intensity. Given that the total or at least large parts of the retail and production infrastructure will be unnecessary, this will significantly contribute to resource savings.
    - Transport: As shown for product-based ecommerce as well as in MIPS (Material Input Per Service Unit) analysis for other services[47], the consumer's choice of transport is of importance for the total material intensity of products or services. Motorised private transportation is far more material intense than public transport or travel by foot or pushbike. Minimising the incentives to use the car (e.g. by reducing the number of parking lots) might help to move more customers toward using ecommerce applications, and thus reduce material intensity.

---

[45] GfK-Onlinemonitor (1999). In: Bundesministerium für Wirtschaft und Technologie [Federal Ministry for Business and Technology]. E-f@cts: Informationen zum Ecommerce. Ausgabe 01/2001 [Information on Ecommerce, Edition 01/2001].

[46] Cathode ray tube.

[47] Hinterberger, F., Liedtke, Ch. et al., (1998). Ökoeffiziente Dienstleistungen als strategischer Wettbewerbsfaktor zur Entwicklung einer nachhaltigen Wirtschaft. [Eco-efficient services as strategic competitive advantage for the development of a sustainable economy]. Final report of the Research Network Ökoeffiziente Dienstleistungen.

- However, reaping the potential savings outlined above is difficult, since businesses and consumer habits as well as rebound effects have counterbalancing effects.
  - Consumers tend to re-materialise digital information. Examples are music files burned on CDs or the tendency to print out most digital documents. The case study on digital music highlighted that this habit might even negate the savings from digital distribution.
  - Download speed and volume are important factors. The longer the download, the higher the material intensity. The case study on digital music shows that downloading large volumes with slow Internet connections can influence the material intensity by several orders of magnitude.
  - Rebound effects. For example, fast Internet connections might change consumer behaviour and increase the overall material intensity on the macro level, as consumers with fast Internet connections are more likely to stay online all the time or to download more files.

Information-based ecommerce has the potential to decouple economic growth from resource consumption. Significant savings on a macro scale are however not expected, for various reasons. First, up-to-date ecommerce is just another sales channel, built up and maintained in parallel to traditional channels. Second, the number of products that can potentially be reduced to an "informational core" is limited. The graphic below highlights the material intensity per capita and year in Germany, categorised according to the most important sectors. It is obvious that housing, food, clothing and community as well as large parts of health and leisure can not be digitised. This leaves only a fraction of the total material intensity where information-based ecommerce can potentially contribute to a decoupling.

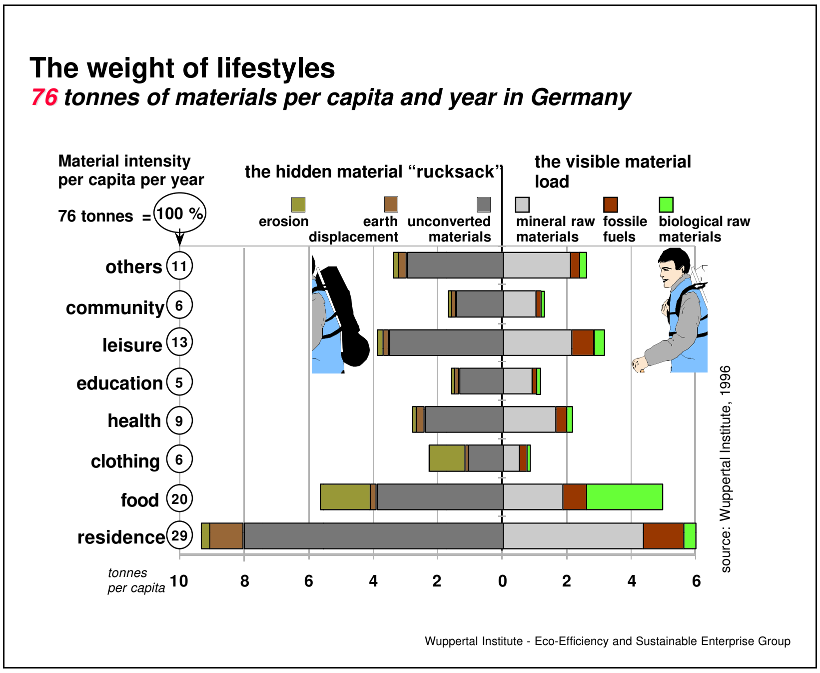


Figure 4-5: The weight of life styles. Material usage per capita and year in Germany (Source Wuppertal Institute).

Third, consumer habits and rebound effects are likely to have a counterbalancing influence. Whether, with changed framework conditions, the benefits can outbalance the risks, remains an open question.

More generally and for both product- and information-based ecommerce, the effects of ecommerce on resource consumption can be characterised by the following key aspects.

- Ecommerce has the potential to decouple economic growth from resource consumption. The framework conditions, like connection speed, type of electricity generation, resource intensity of ICT devices and last but not least consumer behaviour and rebound effects are the decisive factors that tip the balance. Currently it appears that these conditions do not point towards a less material future, in particular since ecommerce is an additional sales channel rather than a real substitute.
- Both product- as well as information-based ecommerce passes through a value chain, from production/provision via retail to consumption/usage. Looking at the distribution of the total material intensity along the value chain in the digital music and online banking case studies, a shift downwards towards the consumption phase can be observed. In other words, taking a life-cycle perspective, the consumption phase plays an increasing role for the environmental effects in an esociety (see figure below). Taking a life-cycle perspective and including the consumption phase is therefore in the future even more important in order to reduce the resource intensity of products and services.

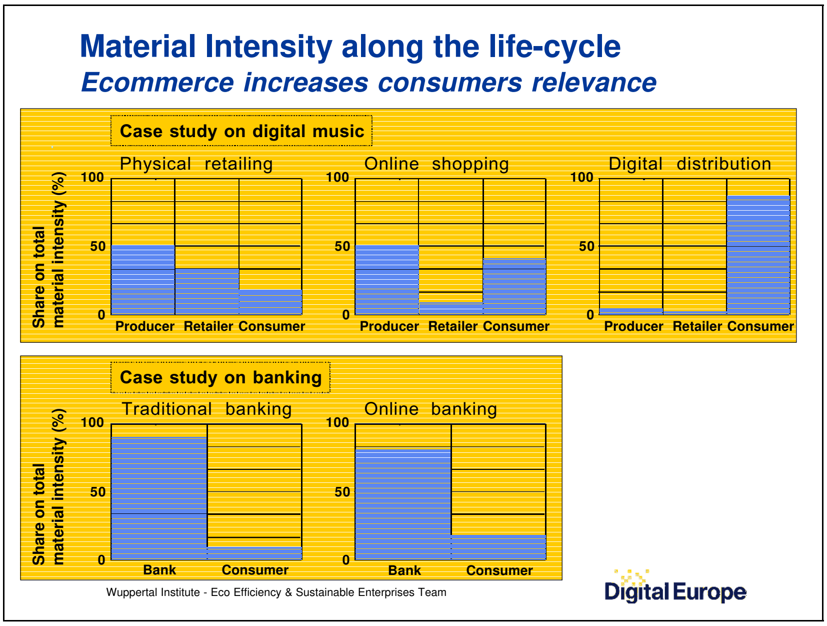


Figure 4-6: Ecommerce and resource consumption in the product'slife cycle (Source Wuppertal Institute).

- The overall relevance of the consumption phase will increase further if consumer habits and rebound effects are included. They might offset the potential savings ecommerce can bring about. Clearly, more research is needed to understand not only the consumption side but also the rebound effects.
- The building infrastructure and energy consumption of service-intensive ecommerce activities, e.g. online banking, are important aspects for the overall material intensity.

4.3.2 Resource consumption by B2B ecommerce

In the last few years B2B transactions have witnessed a rapid growth in various types of market places (emarkets) in which large numbers of buyers and sellers are connected to form online trading communities in order to exchange goods, services and information. In the past the growth rate of B2B ecommerce has been slower than B2C ecommerce; however, for the near future, most forecasts suggest that B2B will eventually account for 80-90 per cent of the value of ecommerce transactions. According to data from Forrester Research, the European Union's (EU) online B2B trade will surge from the 2001 figure of US$ 77 billion to US$ 2.2 trillion in 2006 — increasing from less than one per cent of total business trade to 22 per cent.[48] Other authors assume that the size of B2B ecommerce will grow anywhere from 100 to 1000 times from 1.3 to 12.5 trillion US dollars, dwarfing the more familiar business-to-consumer (B2C) kind by at least a factor of 10. Looking further on, by 2010, it is likely that B2B will grow to account for half of all commerce.[49]

There are a number of differences between B2B and business-to-consumer (B2C) ecommerce which are relevant to the effects on resource consumption. The main differences can be characterised by the value/size per transactions and the buyer-seller relationship. In B2B ecommerce the value of the transaction is generally larger and the buyer-seller relationship is usually based on long-term contracts, whereas in B2C ecommerce the value of transactions is relatively small, including mini orders, and is mostly based on short-term and spot sales.[50] In B2B emarkets many participants interact in a given transaction – networks of suppliers. On the other hand, in B2C ecommerce many consumers deal directly with single sellers (one supplier, many customers).[51] The following figures give an overview of the different forms of electronic transactions between business and business.

---

[48] Greenspan, R. (2002). *EU B2B Expected to Explode*. Online. Available at: http://cyberatlas.internet.com

[49] Chang Yang, Jih. (n.d.). *Environmental impact of e-commerce and other sustainability implications of the information economy*, Working paper of the Research Group on the Global Future, Center for Applied Policy Research. Online available at http://www.cap-info.de/triangle/download/envcom.PDF.

[50] Stiller, H. (2002). In: Andretsch, D., Welfens, P. (2002). *The new economy and economic growth in Europe and the US,* Springer.

[51] See United Nations, *E-Commerce and Development Report 2001*, Chapter 4, p. 64.

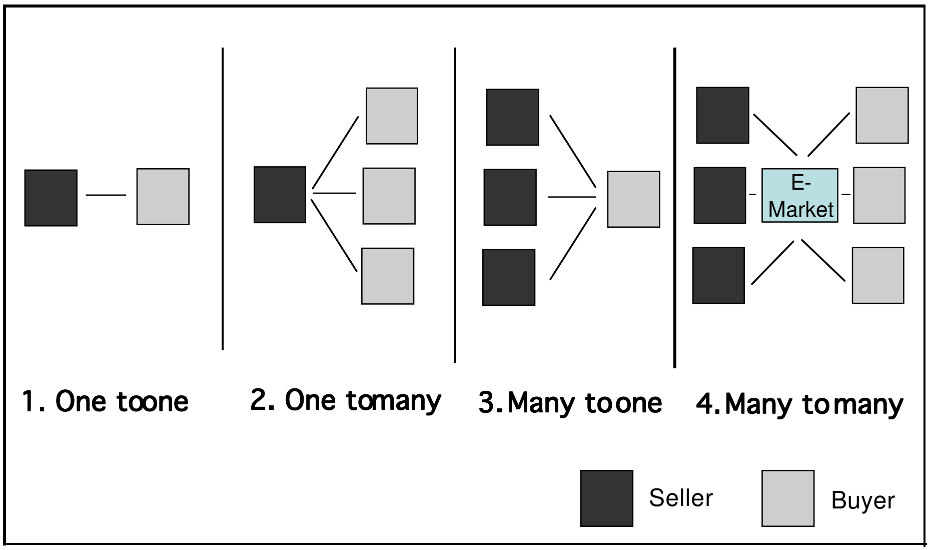


Figure 4-7: Classifications of B2B forms (Source Wuppertal Institute).

Some studies show that Internet-based B2B marketplaces are becoming a dominant force in overall B2B ecommerce.[52] There are now almost a thousand such B2B sites, but these are likely to consolidate in the medium term. According to James[53] emarketplaces vary in operation, but most provide:

- Access to buyers and sellers;
- Auction or tendering mechanisms for individual contracts;
- The means of conducting and completing transactions, often including provision of logistics services; and
- Industry-specific information

Considering these functions, the communication phase seems to be particularly relevant and is discussed in combination with the payment regarding its effects on resource consumption below. Similar to B2C the production and the delivery of the relevant good will also be looked at.

4.3.2.1 Communication and payment phase

The economic advantages of B2B communication within emarkets are obvious. The application of ICT for economic transactions will lead to economic advantages such as greater transparency or a larger geographical scope, reduced transaction costs and an increase in economic efficiency in the supply chain. The communication via B2B platforms intensifies the exchange of information along the supply chain. B2B emarkets offer the handling of online transactions and support for collaboration based on information flows. The Internet plays an important role in improving the informational basis for decision-making in the company. Some companies go further and even integrate their Internet strategies straight from B2C retailing of their

[52] Forrester Research, Inc. (2000). *EMarketplaces boost B2B trade*, February.

[53] James, P./Hopkinson, P. (2001). *Virtual traffic: e-commerce, transport and distribution*, in: Wildson, James (ed.), *Digital futures: living in a dot-com world*, London, p. 173.

products into their internal information systems and on to external B2B supply orders with other companies. Thus, orders from consumers may be electronically transmitted to contractor manufacturers who make the products and ship them directly to distributors and buyers. A range of initiatives are being undertaken by a number of technology companies to develop marketplace applications that can integrate supply chains through emarket networks that include B2B and B2C transactions.[54] Thus, traditional marketing and export channels can be improved and expanded by using the Internet.[55]

Similar to B2C, the establishment of multi-channel communication will induce resource consumption (see section on B2C). The direct impact of the payment in B2B is estimated to be of minor direct importance as the single transaction generally is of larger value and linked to a production of relatively high resource consumption, and the buyer-seller relationship is usually based on long-term contracts which require less information exchange..[56]

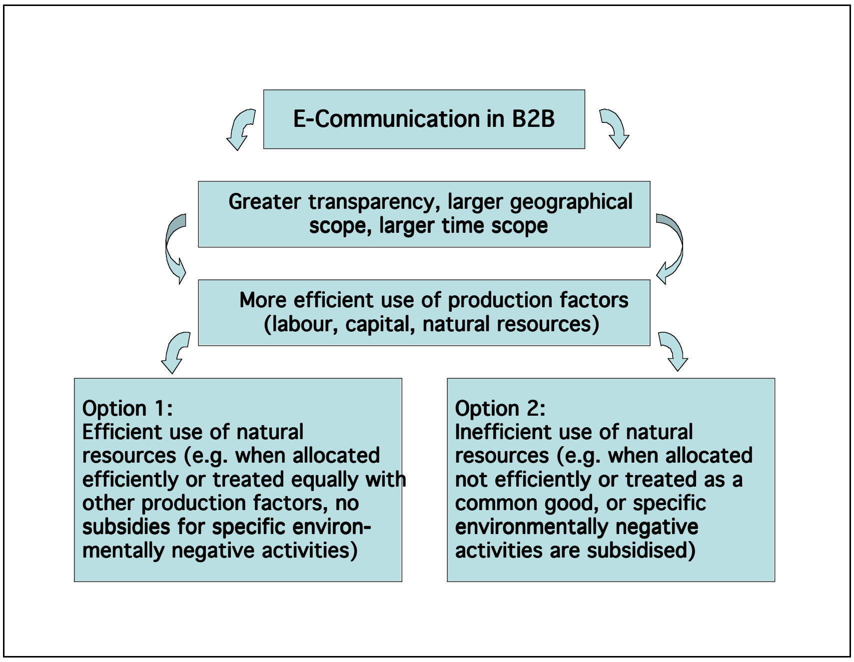


Figure 4-8: Influence of electronic communication in B2B on the use of natural resources (Source Wuppertal Institute).

The indirect environmental effects of B2B platforms are less obvious. With respect to the environment, greater economic efficiency does not necessarily lead to resource efficiency. This is for example the case when the economically attractive use of some production factors is directly accompanied by a greater use of natural resources as another production factor. This leads to the conclusion that the overall impact of ecommerce on resource consumption can be negative as long as specific environmentally negative activities, such as certain modes of transport, are

[54] United Nations, *E-Commerce and Development Report 2001*, Chapter 4, p. 64.

[55] United Nations, *E-Commerce and Development Report 2001*, Chapter 4, p. 64.

[56] Stiller, H. (2002). In: Andretsch, D., Welfens, P. (2002). *The New economy and economic growth in Europe and the U.S.,* Springer.

subsidised or natural resources are not allocated efficiently or are treated as a common good. Theoretically, things might even get worse. In an imperfect market with imperfections in several production factors, a reduction in the distortion in one production factor does not necessarily improve the overall wealth. If the improved transparency and a larger scope of e-exchanges are accompanied by a strong increase in subsidies (e.g. on transportation), induced activities could promote an increase in GDP and at the same time a reduction in the overall wealth. [57]

4.3.2.2 Production and delivery phase

In B2B, there are a number of similarities to production and delivery in B2C; here some aspects specific to B2B will be highlighted. The increased digital exchanges of information between businesses are likely to have a significant impact on business logistics and distribution. Traditional trade is associated with fragmented supply chains. Information tends to flow between individual pairs of parties in the supply chain without transparency across the chain from producer to consumer. By contrast, ecommerce has given rise to greater integration of information and transactions between participants in the supply chain, leading to the creation of distribution networks in which all the participants can share information. This improved information base can potentially be used in order to reduce transport intensity along with resource consumption. However, traditional trade is dominated by the movement of large shipments in bulk consignments, which are already partly optimised. In addition, the demand for shipments tends to be stable and concentrated around a few large buyers.[58] Therefore, the potential for resource efficiency through a reduction in transport intensities is limited (see also chapter 5).

There is some evidence that improved supply chain management can **reduce inventories and stocks**. The lower costs and easier accessibility of Internet-based data exchange can make critical data – such as levels of inventory and orders – available to all players. The result, when combined with enabling technologies such as bar-coding and tracking of items in transit, is a ‘glass pipeline’ that allows a much greater collective knowledge of where goods are, and what will be required in future. For example, firms can use the Internet to forecast demand more accurately, thereby reducing inventory and product waste, as well as the energy and materials required to store and transport products. Even though better inventory management may increase deliveries of smaller goods loads (and there by increase the numbers of trips made), environmental benefits can be expected as a result of reduced stock holdings.[59]

The economic savings from Internet-enabled logistics have already been taken advantage of in some cases. For example, Toyota’s just-in-time delivery system uses the Internet to determine which parts are required where, and at what time, and then converts this information into orders for hundreds of suppliers. According

---

[57] Stiller, H. (2002). In: Andretsch, D., Welfens, P. (2002). *The new economy and economic growth in Europe and the US,* Springer.

[58] United Nations, *E-Commerce and Development Report 2001.*

[59] James, P./Hopkinson, P. (2001). *Virtual traffic: e-commerce, transport and distribution*, in: Wildson, James (ed.), *Digital futures: living in a dot-com world*, London, p. 175.

to Romm[60], the system is able to reduce plant inventories by 28 per cent and energy-consuming warehouse space by 37 per cent. Another example for reducing energy consumption is the use of the Internet to improve shipping systems, as described by Cohen. This example describes that in the automobile business, trucks travel at only 40 per cent capacity at any given time. Ford is investing in Internet-based logistics solutions and telematics to dramatically increase the capacity utilisation of its shippers, reducing the transportation energy required per item shipped.[61] According to the US Department of Transportation, US firms have been able to cut logistics expenditures in half by incorporating information technology. Experts estimate that IT has played a significant role in reducing expenditures on logistics from 20 per cent of US GDP in 1960 to 10.5 per cent as of 1996.[62]

Despite these potential benefits, the move to more integrated supply chains can result in additional resource use. Reduced logistics costs can also create a rebound effect of greater dispersal in supply chains, so that longer distances are travelled. Extension of geographical scope might be less an issue for B2B when compared to B2C as procurement in companies has always been dominated by concerns about costs whereas geographical restrictions have been of little importance. Thus, the effect on additional transport and longer distances might be less severe, although in many cases the electronic platforms might push a further internationalisation as purchasers in industry just did not know about many international supplies and their prices. [63]

Another aspect of electronic exchanges with environmental implications is related to the purchasing criteria which are used. Electronic transactions prefer standardised products. Buyers tend to select the cheapest products. There's no question that the resource efficiency of products and services can theoretically be included into the characteristics of traded products: e.g. a buyer might look for desktop PCs with a very low energy consumption or look at the eco-efficiency of food or different forms of housing. However, at the moment pure price selection dominates the competition on most electronic exchanges. The threshold to more resource-efficient products and services might even be higher as automated procurement might even promote this trend.

For just-in-time delivery. a tighter connection between the different elements within the chain and reduced levels of stock greatly increases the vulnerability to disruption. This was demonstrated by the speed with which the UK petrol blockades of September 2000 disrupted not only fuel supplies but, perhaps more surprisingly, food supplies. This reflects the fact that only limited stocks are held at any one point in the highly efficient UK food chain. Whether positive or negative in their effects,

---

[60] Romm, Joseph, Rosenfeld, Arthur, Herrmann, Susan. 1999. *The Internet Economy and Global Warming: A Scenario of the Impact of E-commerce on Energy and the Environment*. Washington, DC: The Center for Energy and Climate Solutions.

[61] Cohen, Nevin, *E-Commerce and the environment*, in: WWF, *Sustainability at the speed of light*, 2002. pp. 65-66.

[62] Cohen, Nevin, *E-Commerce and the environment*, in: WWF, *Sustainability at the speed of light*, 2002. pp. 65f.

[63] Stiller, H. (2002). In: Andretsch, D., Welfens, P. (2002). *The new economy and economic growth in Europe and the US,* Springer.

just-in-time delivery is likely to develop further.[64]

As an effect of the economic advantages and the increased competition, prices will also be reduced significantly.[65] As prices fall, demand and consumption of production and services will rise, along with the use of natural resources for production and delivery. And in the case of no improvements in the efficiency of the production chain, the accelerated consumption will lead to negative ecological impacts.[66] Thus there is the need for incentives to use less natural resources.

4.4 Resource consumption by egovernment

ICT use in governmental procedures is growing and an increasing number of government institutions intend to offer new and improve existing electronic services (egovernment). Egovernment therefore marks another high-ranked field in the transition to an information society, as the public discussion and several action plans show[67]. Since the mid-1990s governments around the world have launched major initiatives in order to tap the vast potential of the Internet for the specific purpose of improving the governing process. Like the personal computer 10 years ago, the Internet has become an indispensable tool in the day-to-day administration of government. Over 90 per cent of world-wide governments claim to have at least one official website, with about the same number claiming to have promoted ICT use through government initiatives.[68] In 2001, 169 of the 190 UN Member States (88.9 per cent) used the Internet in some capacity to deliver information and services.[69] European countries are among the leaders of the process, with 14 out of 15 EU Member States ranked in the highest category in "The 2001 e-Government

---

[64] James, P./Hopkinson, P. (2001). *Virtual traffic: e-commerce, transport and distribution*, in: Wildson, James (ed.), *Digital futures: living in a dot-com world*, London, p. 174.

[65] Chang Yang, Jih. (n.d.). *Environmental impact of e-commerce and other sustainability implications of the information economy*, Working paper of the Research Group on the Global Future, Center for Applied Policy Research. P. 3. Online available at http://www.cap-info.de/triangle/download/envcom.PDF

[66] Chang Yang, Jih. (n.d.). *Environmental impact of e-commerce and other sustainability implications of the information economy*, Working paper of the Research Group on the Global Future, Center for Applied Policy Research. p. 3. Online available at http://www.cap-info.de/triangle/download/envcom.PDF

[67] cf.: Cabinet Office: e-government. A strategic framework for public services in the Information Age, Crown copyright (UK) 2000

[68] UNESCO, COMNET-IT (n.d.): *On-line Governance Survey Report – A joint UNESCO and COMNET-IT Project*, n.d., p. 31.

[69] United Nations Division for Public Economics and Public Administration. (2002). *Benchmarking E-Government: A Global Perspective Benchmarking – Assessing the Progress of the UN Member States*, p. 10. The report differentiates egovernment services from "emerging", which implies "a government web presence is established through a few independent official sites. Information is limited, basic and static" up to "seamless", where a "total integration of efunctions and services across administrative and departmental boundaries" exists. Steps towards a seamless service are regular updates, interactive elements and possibilities to process financial transactions online. According to UNPAN, today no government offers "seamless" egovernment, and only 17% reach the second highest category named "transactional".

Index".[70] Generally there is a recent increase in government ICT expenditure,[71] which reveals the dynamics of egovernment.

Till now, systematic assessments of the implications of egovernment for the environment are rare[72] – especially those which take into account wider impacts resulting from behavioural changes or societal developments linked to the introduction of egovernment. Considering the classification of effects by general ICT application stated above, environmental impacts consist of direct effects from infrastructure, secondary effects from the application and tertiary effects (re-bound and structural change). Effects on resource consumption described below occur in the electronic interaction between government and different actors: in internal operations (including G2G (government to government), G2C (government to citizen), and G2B (government to business)).

Generally, the analysis shows that the egovernment environmental aspects have some similarities to the service-based ecommerce as described in the previous section. This is based on the fact that the services of egovernment have an informational core. Thus, for the description of the effects, only specific aspects of egovernment will be highlighted.

4.4.1 Internal operations and G2G

In general, egovernment is seen as an important catalyst to **modernisation of government** and administration[73]. Introduction of egovernment can help to overcome resistance to reshaping government structures by combining the introduction of ICT, which is generally accepted, with general restructuring: "Basically, egovernment is a driving force for reforms"[74]. This general modernisation can lead to more efficiency in general and introduction of sustainable management measures, thereby fostering sustainable development. Increased efficiency and thereby decreased working hours in public buildings lead to reduced resource

---

[70] United Nations Division for Public Economics and Public Administration. (2002). *Benchmarking E-Government: A Global Perspective Benchmarking – Assessing the Progress of the UN Member States*, p. 7.

[71] UNESCO, COMNET-IT (n.d.): *On-line Governance Survey Report – A joint UNESCO and COMNET-IT Project*, n.d., p. 9, 13 and 14.

[72] One study has been conducted regarding effects on climate change, based on data for Japan: Miura, H., et al., (2002): *Analysis of the Effect of Local e-Government on Climate Change, In: Proceedings of The Fifth International Conference on EcoBalance – Practical tools and thoughtful principles for sustainability*, Nov 6 – Nov 8, 2002. EPOCHAL TSUKUBA, Tsukuba, Japan, p. 443.

[73] Bundesministerium des Innern, Stabsstelle Moderner Staat – Moderne Verwaltung, (2001). *BundOnline 2005 – Umsetzungsplan für die e-Government-Initiative* [BundOnline 2005 – Action plan for the egovernment initiative] Berlin, December 2001. p. 9.

[74] Pröhl, Marga (2002). *Expertin: E-Government ist Motor im Reformprozess der Verwaltungen* [Egovernment is the engine of reform process of the administration offices]. IfG.CC – Institute for e-Government.
Interview available at http://www.e-lo-go.de/html/modules.php?name=News&file=article&sid=1024

consumption in heating and energy consumption. Miura at al. estimates the savings in Japan to be 7.6 per cent, using CO_2-reductions as the indicator.[75]

Egovernment implies **primary impacts caused by communication infrastructure**, both individual office equipment and common server and network structures, which are similar or identical to impacts caused by the introduction of ICT into corporate operations. The number, type and use of office equipment are important parameters when considering impacts on resource consumption and are likely to change in upcoming years. Miura et al. estimate the average number of workers per computer to drop from the current 1.45 to one[76], linked to increases in material intensity by production, transportation, use and disposal phases. As shown in a case study, environmental impacts can be reduced when multiple users share common hardware units: The benefits estimated there present an indication for strategic actions when shaping the egovernment future. Taking application service provider solutions and flexible office solutions into account from the beginning can help to avoid drawbacks in resource consumption at an early stage and cut costs in procurement and maintenance.

The introduction of egovernment leads to **offering services in redundant ways.** Each channel is associated with a certain amount of resource consumption, which can add up to a higher total output. As a result, future developments in multi-channel strategies will implicate ecological risks of increased resource consumption for the necessary infrastructure.

The **building needed** for governmental services is a part which needs to be considered for the evaluation of egovernment's environmental effects, considering the experiences of the case studies. Ways to reduce the related resources used can be manifold. The efficient management of office space (e.g. regarding heating and electricity use) is one option for saving resources. From the environmental viewpoint it might even be preferable to use the office space for other purposes, however this might have social consequences. As some office space is used for paper storage and handling, the reduction in paper intensity might be another option.[77] In Japan, paper used by local governments is estimated at 82 thousand tons for internal business and 158 tons for external requests.[78] Here egovernment applications can

---

[75] Miura, H., et al., (2002): *Analysis of the Effect of Local e-Government on Climate Change, In: Proceedings of The Fifth International Conference on EcoBalance – Practical tools and thoughtful principles for sustainability*, Nov 6 – Nov 8, 2002. EPOCHAL TSUKUBA, Tsukuba, Japan, p. 443.

[76] Miura, H., et al., (2002): *Analysis of the Effect of Local e-Government on Climate Change, In: Proceedings of The Fifth International Conference on EcoBalance – Practical tools and thoughtful principles for sustainability*, Nov 6 – Nov 8, 2002. EPOCHAL TSUKUBA, Tsukuba, Japan, p. 443.

[77] The British insurance company Royal & SunAlliance claims that its online procurement system has improved the efficiency of its purchasing and is saving 1.7 million sheets of paper a year. (Wilsdon, J. (2001). Also, electronic billing is growing in acceptance as it saves an estimated 50 to 75 cents per bill in envelopes and postage, and another US$1 in handling costs. This and further examples of positive ecological and economic effects by increased electronic information systems are given by Cohen, N. (2001).

[78] Miura, H., et al., (2002): *Analysis of the Effect of Local e-Government on Climate Change, In: Proceedings of The Fifth International Conference on EcoBalance – Practical tools and thoughtful principles for sustainability*, Nov 6 – Nov 8, 2002. EPOCHAL TSUKUBA, Tsukuba, Japan, p. 443

help to reduce the amount of paper handled as well as office space needed. Regarding the internal operations, a centralised data service might help to minimise repetition of (printed) information. Websites or other data services can help to provide up-to-date information on supplies fulfilling the procurement standards (whether qualitative, environmental, ethical or another type of criteria) set. The amount of savings depends on the integration of ICT. Electronically delivered forms which have to be printed out clearly result in re-materialisation. Savings of paper and office space are greater if data is stored and processed exclusively in electronic form internally. However, UNPAN states that "national egovernment programme development remains desultory and unsynchronised"[79]. Lack of coordination between departments may ultimately "compromise programme effectiveness and performance efficiency", which points to the need for central coordination of egovernment efforts to provide a single access point and to build an integrated, cross-boundary ICT system.

Cooperation between both national and international governmental organisations is often hindered by the high economic cost of face-to-face consultation, which is necessary in the field of policy development and implementation, e.g. the harmonisation of environmental and social standards. ICT can provide a way to better coordinate national and international efforts. Big conferences like the World Summit in Johannesburg which demand a lot of air travel might not be necessary in the future as interaction between governmental organisations takes place on a day-to-day basis leading to higher levels of interaction which in turn result in better international stakeholder dialogues and policies. Especially in multi-layered decision-making bodies like the European Union and its Member States, ICT can improve stakeholder dialogues and reduce resource consumption side-impacts, e.g. from travel[80]. However, these improvements are subject to rebound effects similar to the rebound effects that occur, for example, in business video-conferencing:[81] More contact through ICT between different groups located world-wide might lead to an increase in travel, as not all personal interactions can be substituted by electronic equivalents. Some electronic communication may run parallel to or even generate travel. Positive policy outcome of international cooperation can thereby easily be levelled out by transportation impacts.

[79] United Nations Division for Public Economics and Public Administration (2002). *Benchmarking E-Government: A Global Perspective Benchmarking – Assessing the Progress of the UN Member States*, p. 3.

[80] An example of a EU consultation process in the field of environmental policy is described in Westholm, H. (2000). *Perspektiven einer virtuellen Demokratie*, [Perspectives of a virtual democracy] In: Schneidewind, U., Truscheit, A., Steingräber, G. (2000). *Nachhaltige Informationsgesellschaft, Analyse und Gestaltungsempfehlungen aus Management- und institutioneller Sicht*. [Sustainable Information Society, Analysis and policy proposal from a management and institutional point of view] Metropolis-Verlag, Marburg 2000, p. 163.

[81] Arnfalk, P. (2002) *Information and communication technologies and business travel – Environmental possibilities, problems and implications*, In: Park, J., Roome, N. (2002) *The Ecology of the New Economy – Sustainable transformation of global information, communications and electronics industries*, Greenleaf Publishing 2002, p. 188 f.

4.4.2 Government-citizen interactions (G2C)

Government interaction with citizens on the administrative level is almost exclusively concerned with information, which allows comparisons with information-based ecommerce as described above. G2C is likely to enable resource savings in the area of personal traffic; however, the ICT equipment to be used by the citizen will potentially increase the overall resource consumption.

The effects of G2C on resource efficiency are **similar to those noted in the case study on banking**, where one scenario with a counter transaction is compared with one with digital data transmission. Banking, being a service as well as public administration, turned out to be dominated by the material intensities of the buildings' infrastructure. If we extend the case study results to egovernment it seems probable that the reduction in floor-space will be an important improvement area. To what extent egovernment will be able to contribute to this goal, is not yet known. Estimations are difficult and rely on the national administrative traditions and procedures.

Similar to the banking sector, the provision of governmental services to citizens will to a certain degree always rely on **personal interactions with citizens**. As an illustrative example regarding the environmental consequences: in some German municipalities[82].citizens have to travel up to 70 kilometres to register a new private car. The required fuel consumption is related to 6 kg of abiotic resources and 40 litres of water. In this context, egovernment applications offer the possibility to increasingly reduce the need for face-to-face contacts with administration. For Japan, Miura et al. estimate that vehicle traffic linked to local government activities may be reduced by 50 per cent through egovernment.[83]

However, transport resulting from governmental services contributes to only a very small share of all trips travelled and consequences will therefore remain marginal. A survey of internet portals of medium sized and big cities reveals that the majority of information that they provide relates to additional information services, like information on the community, how to access offices and officials, calendar of events, etc. Rankings of European city internet portals also emphasize the goals of creating a city image and making the location attractive to the visitor and inhabitant[84]. Compared to the functions mentioned above, e-services that would render a trip to the administration unnecessary are rare. Significant transport savings can therefore not be expected.

In the long run, the introduction of egovernment can lead to pressure on citizens to buy their own ICT equipment to effectively take part in government procedures or to benefit from egovernment, thereby generating direct impacts through the more intensive use of ICT. The closing of regional governmental agencies to reduce

---

[82] Shuppan, T., Richard, Ch. (2002). *Neue Verwaltungsmodelle braucht das (Flächen)Land: Verwaltungsmodernisierung mit E-Government* [The country needs new administration models: modernisation of administration by egovernment], In: *Technikfolgenabschätzung – Theorie und Praxis* Nr. 3/4, 11. Jg., November 2002, p. 40.

[83] Miura, H., et al., (2002): *Analysis of the Effect of Local e-Government on Climate Change, In: Proceedings of The Fifth International Conference on EcoBalance – Practical tools and thoughtful principles for sustainability*, Nov 6 – Nov 8, 2002. EPOCHAL TSUKUBA, Tsukuba, Japan, p. 443.

[84] cf. European E-City Award 2002, at: www.eec-award.com, and: www.eec.pixelfarmers.com

impacts from administrative buildings will promote this development, which could be moderated by local ICT centres offering public access to ICT. Public ICT kiosks are offered by 27 per cent of governments running policies to increase ICT literacy, one early starter example is online kiosks offered by the Portuguese INFOCID initiative[85]. Government subsidies for ICT equipment, offered by 18 per cent of governments to improve ICT literacy, might lead to over-consumption of electronic devices and thereby increased environmental impacts.

4.4.3 Government-business interactions (G2B)

Indirect impacts in the government-business relationship occur on different levels as businesses deal with government in different positions with relation to the flow of natural resources.

Seeing corporations as **supply partners**, ICT use by government bodies can improve resource impacts from the logistics systems and the suppliers. Here ICT can promote control of standards-setting and regulatory oversight.[86] Application of egovernment can also help to utilise more effective green (and ethical) procurement strategies.[87] Here, the handling of greater amounts of data is made possible by ICT – e.g. resource efficiency can be integrated as procurement criteria. Better data basis and comparability as well as better information on public requirements leads also to more transparent procurement, fostering business efforts to take advantage of compliance with green procurement as a competitive advantage.

"Corporate citizens" are subject to rules and norms by government. Thus, for corporations taking part in administrative procedures, the results are mainly the same as shown above for the private citizen. Potential resource savings from introducing egovernment in G2B might even be higher, as personal consultation is less important in state interaction with professional actors than with normal citizens[88].

---

[85] UNESCO, COMNET-IT (n.d.): *On-line Governance Survey Report – A joint UNESCO and COMNET-IT Project*, n.d., p. 18. See also Vidigal, Luis (1999). *INFOCID – A single window for citizenship in Portugal*, In: *Democracy and Government On-Line Services – Contributions from Public Administrations Around the World – a G8 GOL publication*, http://www.statskontoret.se/gol-democracy/portugal.htm

[86] Sarkis, J., Meade, L., Talluri, S. (2002). *E-logistics and the natural environment*, In: Park, J., Roome, N. (2002). *The Ecology of the New Economy – Sustainable transformation of global information, communications and electronics industries*, Greenleaf Publishing 2002, p. 49.

[87] Simply using the requirement of Environmental Management Systems by the supply partners appears to be sometimes relatively ineffective. For this discussion see Wuppertal Institute, (2002). *Review of Eco-Efficiency Concepts in Europe – Towards an Application of European-Based Policies on Material Flows and Energy to Japanese Sustainable Development Policies, Final Report*, January 2002, p. 63.

[88] Lenk, K. (2000). *Dienstleistungssysteme und elektronische Demokratie.* [Service Systems and Electronic Democracy] In: Schneidewind, U., Truscheit, A., Steingräber, G., (2000). *Nachhaltige Informationsgesellschaft, Analyse und Gestaltungsempfehlungen aus Management- und institutioneller Sicht.* [Sustainable Information Society, Analysis and policy proposal from a management and institutional point of view] Metropolis-Verlag, Marburg 2000, p. 143.

On a more general level, ICT enables stakeholder involvement, especially with companies, which can lead to better policies and their implementation (e.g. voluntary agreements or reporting). Transparent and open consulting procedures that are practised today by non-governmental regulation bodies like the Global Reporting Imitative and supported by the use of ICT[89], could be a future model for government decision-making in new governance networks, resulting in a wider acceptance of standards and regulations that are easier to implement and control. Real-time feedback, e.g. suggestions and complaints by citizens, can be used to start learning processes[90].

4.5 Conclusions

Concluding on Digital Europe's research at the micro level, it becomes apparent that the effects of ICT and ICT applications are complex and caused by a number of factors, e.g. by the ICT infrastructure, the application or by changed consumption patterns. The related research body is growing but assessments of the dematerialisation potential of ICT equipment and its application are still scarce. The case study approach taken within *Digital Europe* as well as the desk-based research helped to shed some light on this issue and identified first influential factors for the resource consumption of ebusiness. It is important to emphasise that ebusiness is not purely virtual and strongly linked to the use of natural resources. Key factors of ICT applications that have been identified as influencing the environmental effects and in particular the material intensity are outlined below.

Today, ICT seems to be an inevitable element of modern society. Considering the current growth in **ICT infrastructure** and the associated consumption of natural resources, it is necessary to promote more resource-efficient ICT infrastructure and applications. However, the demand for eco-efficient ICT products is currently low, the same is true of consumer awareness regarding the environmental impacts of ICT. In addition, the availability of life-cycle-wide data for ICT devices has been confirmed to be low. Even the case study partner has had considerable difficulties in obtaining data from suppliers. Reasons might be the complexity of the supply chains and the short innovation cycles of digital products. Environmental accounting at the product and business level - as linkage between economic and environmental data – is increasing in importance as a means of improving the data availability but also the awareness of the life-cycle wide environmental impacts of ICT devices. Design for the environment is of great importance because at the product development phase the main environmental effect of the entire life cycle is determined. Opportunities to facilitate improvements include, the use of secondary materials, the extension of the ICT´s lifespan or the shared use of ICT equipment.

The **miniaturisation of ICT** products seems not to be "the" solution as it might be related to the additional use of natural resources. Small scale ICT products are potentially used as add-ons or substitutes for more efficient products. Compared to larger ICT products, smaller devices incorporate an increasing share of functional

[89] www.globalreporting.org

[90] Lenk, K., (2000). *Dienstleistungssysteme und elektronische Demokratie*. [Service Systems and Electronic Democracy] In: Schneidewind, U., Truscheit, A., Steingräber, G., (2000). *Nachhaltige Informationsgesellschaft, Analyse und Gestaltungsempfehlungen aus Management- und institutioneller Sicht*. [Sustainable Information Society, Analysis and policy proposal from a management and institutional point of view] Metropolis-Verlag, Marburg 2000, p. 147-148.

materials, which have larger ecological backpacks relative to other materials. In addition, miniaturisation (and pervasive computing) leads to difficulties regarding their end-of-life management. As the material value of smaller products is reduced and the smaller size of the device allows them to be discarded with household waste, then the take back and recycling systems face major challenges. Research is needed to develop appropriate recycling strategies for sustainable resource management.

Energy consumption, and more specifically electricity consumption turned out to be a significant factor in the material intensity of ebusiness. According to the case study findings, the material intensities of fully digitised ecommerce scenarios, consumed between 40 and 70 per cent of overall electricity use. This high a percentage of electricity use was not expected.

Ecommerce, as one important application of ICT, can – under specific circumstances - provide significant resource efficiency potentials. A categorisation between **product-based and information-based ecommerce** turned out to be helpful to differentiate the dematerialisation potential. Information-based, i.e. not based on any physical product but on information only, can be considered advantageous compared to product-based ecommerce. In particular commerce types that can potentially change from product-based to service-based hold a significant dematerialisation potential. A music-server for example can provide a tremendous number of service units to many consumers and online music has therefore a low material intensity per service unit. Other examples of dematerialised products are centralised voice mailing servers,[91] or news servers.[92] It is not only the product as such, but also resource flows connected to the production and retail infrastructure as well as to transportation that are made redundant. In particular, resource savings at the building infrastructure and land-use might turn out to be of interest. Regarding product-based ecommerce, the possible dematerialisation potentials appear to be small. The case study findings suggest that product-based ecommerce might even be more resource intense than traditional retailing business.

While **information-based ecommerce** has the potential to decouple economic growth from resource consumption, significant savings on a macro scale are not expected, for various reasons. First, up to date ecommerce is just another sales channel, built-up and maintained in parallel with the traditional channels. Second, the number of products that can potentially be reduced to an "informational core" is limited. In the sectors of building, food, clothing and community as well as large parts of health and leisure most products can not be digitised. This leaves only a fraction of the total material intensity, in which information-based ecommerce can potentially contribute to a decoupling. Third, consumer habits and rebound effects are likely to have a counterbalancing influence. Whether, with changed framework conditions, the benefits can outweigh the risks, remains to be seen.

Regarding **egovernment**, there are a number of similarities to the information-based ecommerce in B2C, as most governmental services have an informational

[91] Reichling, M., Otto, T. (2002). Environmental Impact of the New Economy, In: Park, J., Roome, N. (Eds.) Ecology of the New Economy. Greenleaf.

[92] Reichart, I., Hischler, R., Schefer, H., and Zurkirch, M. (2000). Umweltbelastung durch Internet-Surfer, Fernsehzuschauer und Zeitungsleser [Environmental impacts of surfing the Internet, watching TV and reading a newspaper]. Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), 2000.

base and are aimed at a large number of single actors. Consequently, egovernment provides opportunities for de-materialisation by reducing primary and secondary effects on resource consumption. Potential opportunities seem to be for example the greening of the used ICT infrastructure (and its use), personal transport savings or the reduction of office space. The third order effects (e.g. improved policy integration through ICT-enabled stakeholder involvement or changed consumer behaviour through ICT-based control mechanism) are hard to even estimate, and sometimes somewhat speculative.

There is no mechanism to ensure eco-efficiency improvements through e-Government. However, as most countries are still at an early stage of development and in an experimental phase, future implementation of opportunities is viable. Research initiatives are therefore needed to assess today's impacts and to lay a path to future sustainable development – as the speed and the early stage of development opens opportunities to influence decision makers in the planning phase. This makes efficient, sustainable strategies more likely, as no sunk costs of past developments have to be overcome,[93] but development can be shaped in a holistic manner. It should be stressed again that ICT-implementation also provides an opportunity to re-structure processes in general (as described in 4.4.1), offering chances for dematerialisation from general efficiency and the introduction of sustainable management measures.

When comparing the different forms of ecommerce and egovernment with respect to their resource saving potential, the size of transactions seems also to be of importance. The economically important B2B and B2C ecommerce will be more relevant for a decoupling than egovernment, as economic and material flows linked to ecommerce are greater.

However, whether or not the resource efficiency potentials can be reaped depends to a large extent on **businesses and consumer habits,** as well as rebound effects, which are likely to have a counterbalancing effect. As with many other technical applications and services the rebound effects are important to consider in order to evaluate the full picture of environmental effects by ICT and ebusiness. While on a case study level they might not be of relevance, on a macro level they probably are. A few examples are:

- the Internet will reframe markets, enabling companies and consumers to buy globally, which potentially increases transport demands;
- flat rate internet access might reduce the (economic) incentives for web users to disconnect from the Internet between sessions, resulting in an increasing energy demand, even if the PC itself is in sleep mode;
- fast Internet connection might change consumer behaviour and increase the overall material intensity, as consumers with a fast Internet connection are more likely to stay online or to download more files.
- consumers tend to re-materialise digital information. Examples are music files burned on CDs or the tendency to print out most digital documents. The case study on digital music highlighted, that this habit might even negate the savings from digital distribution.

[93] This is only partly true for most first-world countries, where dis-integrated ICT systems may already exist.

In particular the last bullet point (consumers tend to re-materialise) is a good illustration of how consumer habits are still very much rooted in a non-digital world. Information stored only on a remote server or hard-drive will be burned onto a CD or printed out on a regular basis. Reasons for this are manifold, they includes issues such as trust (is the information safe; is a back-up needed), traditions (important information needs to be filed as a print out), habits (to work with long documents requires a print out) and so on.

Even though the case study findings suggest that ebusiness applications are less material intense, ebusiness is not better or worse than traditional business methods per se. In particular in a transitional phase, where ebusiness channels are built up in parallel to existing ones, ebusiness is likely to be an additional consumer rather than a substitute. However in the long(er) run, consumers may get out of the commerce habits that they are presently set in, leading to a true substitution and thus dematerialisation. However, for this to happen, it is not only the consumer that needs to adapt, but also business will have to put a lot of effort into developing applications that fit consumer needs and habits. Technology needs to adapt to its users. With the growth of the Internet, global and national framework conditions become more important as a means of limiting undesired rebound effects, such as additional transport or energy consumption.

5 Virtual Transport? - ICT applications and transport efficiency

5.1 Introduction to ICT and transport

Transport is widely recognised as a key issue for economic wealth as well as for ecological and social values. Modern ICT has the potential to allow fundamental changes to the established transport system: Information transport by wire, or beyond that even without cables & wires obviously can substitute both passenger and freight transport, as far as persons or goods were transported as vehicles for information. In addition, ICT has many other consequences on transport, mostly positive ones but sometimes more negative ones. Therefore, it makes sense to discuss the consequences of ICT on transport in more depth. The following paragraphs firstly draw attention to the different areas, in which ICT and transport interact. They then focus on transport effects in the field of B2C ecommerce (teleshopping) and telework.

Relationship between ICT and transport

Research knowledge of the effects of ebusiness on logistics and transport systems is particularly patchy. Existing case studies offer a broad range of, at times conflicting, results. Digital Europe will analyse the transport-related impact of different types of ebusiness application drawing on existing research in order to obtain a basic view of the overall impact of ebusiness on transport efficiency. Further analysis will attempt to establish the key factors which determine the impact of ebusiness on the efficiency and intensity of transport and logistics.

Conceptualising ICT and transport is complex, since both, ICT and transport, run through virtually every aspect of life. Therefore, overlapping and interlaced effects are quite common and show the need for a systemic approach. For the analytical purpose at hand, the following systematic overview may offer a structure that is not too simplistic. Here, the processes and effects are divided into four groups.

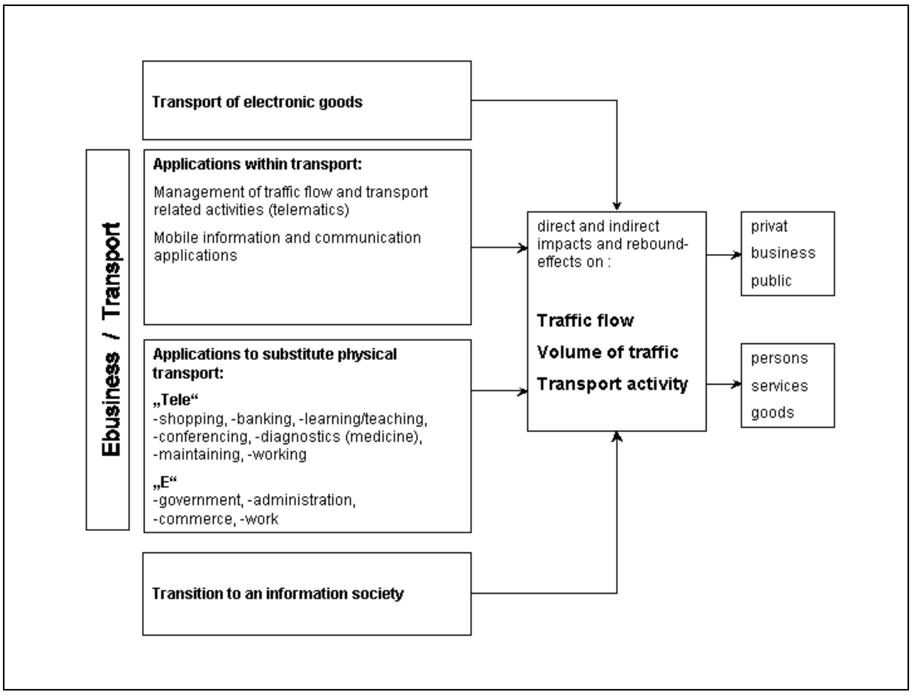


Figure 5-1: Main areas of interdependencies between ICT and transport (Source: Wuppertal Institute).

Transport of electronic goods

The first group covers the transport of ICT itself. The full scope will reach “from cradle to grave“, as carried out for the material flows. This leads to further divisions into three phases, the first phase covers the processes involved in producing ICT goods and bring them to their place of activity and is the phase that has traditionally received most attention. The second phase covers transport during the time of usage, e.g. service and maintenance, repair and upgrades etc. Finally, the third phase deals with transport after the useful life of ICT goods.

After initial analysis, ICT goods show significant differences compared to other products like foodstuffs or building materials. Very large scale production plants (in terms of large numbers of typically small items produced), globalised trading and a global economy result in an antagonistic structure of long distances and minor volumes or weight. Big and growing numbers and frequent replacement add further aspects, as well as complex production schemes.

The data presently available on these issues is on the whole rather weak. While a wide range of timely information is available it is difficult to generate an overall picture. Additional difficulties arise from the rapid pace of change which shows few signs of abaiting. Fundamental uncertainties for the outlook result from the fact that the functional division between hard- and software is clear for products on the markets, but not for future concepts.

Applications within transport

The second group deals with ICT in transport and can be divided into two subgroups, the ICT-applications used for transport on the one hand, and the ICT-applications used during transport on the other hand. Both of them cover a wide range of individual technologies.

The ICT-applications which support transport are commonly subsumed under the concept of telematics. Traffic guidance, route optimisation, GPS-coupled navigation, electronic based road pricing are some of the key words that have been broadly discussed in recent years. With reference to freight transport, the respective applications tend to connect transport and production elements, via just in time (JIT) and ambitious logistics concepts.

While the positive effect on transport is by and large obvious, the range of improvement is not that clear – especially for road transport. Unlike air, ship and rail transport, the results for road transport up to now show a more mixed outcome. However, to whatever extent it is possible to minimise present shortcomings, possible rebound effects must also be considered. A significant improvement in the level of service generally will create additional transport if compensatory action is not taken.

The ICT-applications used during transport are known as “m-technologies“ (for mobile use) and represent a core element of recent developments. Again, the range of devices and their functions is wide and rapidly-changing. As public interest in this issue is very high, many claims have been made concerning the current and future possibilities of m-technologies. Nevertheless, the real prospects are not easy to predict. This creates difficulties and uncertainties for the industry as well as for scientific research.

In this area, again, possible rebound effects have to be considered. Enriching time spent travelling with additional activities and features such as internet surfing and office work etc. may result in changing attitudes to travel, in particular raising tolerance of long transport times and distances.

ICT to substitute physical transport

The third group addresses the main topics that Digital Europe is dealing with, commonly known as the modern e-, or telebased technologies. Again, several subgroups can be identified:

With respect to **ecommerce** the area of B2C ecommerce or teleshopping will be looked at in detail. Case study research described in chapter 4 indicated that private transport might be of particular relevance to the total material intensity of B2C ecommerce. This chapter will discuss the transport-related aspects of B2C ecommerce in more depth. B2B ecommerce and its effects on transport are dealt with in chapter 4, as one aspect of the material intensity analysis.

The other big issues related to ebusiness can be subsumed under the **telework topic**. Telework can be broken down into home-based telework, teleconferencing and mobile work. Related aspects were dealt with in the telework case study with a specific focus given to transport, as described further down.

A further group is created by **egovernment**, which was not in the foreground of this study and not supported by case study research. Aspects related to transport are covered in chapter 4. Other fields, beyond these groups, like e-learning or tele-maintaining may receive more attention in the future. However, they are no specifically addressed within the Digital Europe Project.

Transition to an information society

The fields briefly described above show direct connections to the transport systems, though in different ways. In addition we have to be aware of consequences on the transport systems, which follow from the general transition to an information society. ICT broadly influences industrial production and is responsible for massive changes in that area, as is well known. Obviously, commuting is no longer necessary for those parts of the work force that are substituted by computers. Also, for the private environments, the increasingly generalised use of computers and the Internet may substantially change habits, with the respective consequences on transport. The wide scale of consequences cannot be analysed here. Nevertheless, we have to be aware of the structural changes, in particular, when it comes to future outlooks.

5.2 Transport and B2C ecommerce

Published material discusses controversially, whether B2C ecommerce[94] tends to generate transport savings[95] or to stimulate additional transport.[96] This section will look at this question, considering the case study results as well as the desk-based research.

5.2.1 Limits to transport saving at the micro level

There are a number of limits to the transport savings that B2C can bring about at the micro level. In order to understand the scope of potential transport savings by B2C it is helpful to consider the different phases of the economic transaction, as illustrated in Chapter 4, though the various steps are not always realised, especially when buying everyday goods in everyday life. Though the communication and payment phase are purely informational and can be carried out electronically, some steps are not purely informational. If the good itself consists of physical material (product-based ecommerce) the delivery phase will need to be carried out physically.

In addition, as mentioned in Chapter 4, B2C ecommerce makes up only a small share of the total supply of goods to customers, though growth of that share is significant.[97] As an example of the limits to B2C, a study by Transport and Logistiek

[94] The terms B2C ecommerce and teleshopping are used as synonyms.

[95] Jönson, Gunilla & Johnsson, Mats. (2001). Electronic commerce and distribution systems. Lund Institute of Technology.

[96] van Leewen, Robert. Transport en Logistiek Netherlands: New Wine in Old Bottles – Argument in Favour of More Space for Road Haulage to Accomodate the Growth of New Economy; paper presented at the Joint OECD/ECMT Seminar "The Impact of E-Commerce on Transport, Paris 5/6 juin 2001.

[97] Figures given in the Literature often deal with the value of goods purchased, which of course is not very relevant from a transport perspective, in particular if in some cases the impressive totals are dominated by financial transactions. The latter group of e-services definitively should be grouped

Netherlands is based on the assumption that the consumer will buy 15 per cent of non-food products and ten per cent of food products through e-shops in 2005 [98]. This estimation appears to be rather optimistic.

Also the in-depth interviews regarding the effects of internet-based shopping pointed out a limited potential for transport savings. The interviews were carried out with two firms. The results are highlighted in the following two boxes.

separately, bearing in mind, that special travel for conducting financial transactions is of no particular importance within the distances travelled privately.

[98] van Leewen, Robert. Transport en Logistiek Netherlands: New Wine in Old Bottles – Argument in Favour of More Space for Road Haulage to Accomodate the Growth of New Economy; paper presented at the Joint OECD/ECMT Seminar "The Impact of E-Commerce on Transport, Paris 5/6 juin 2001.

Box 5-1: Interview with large mail order company

The mail-order company interviewed is active on a global scale and is a pioneer in internet-based shopping as well as in the ecological benchmarking of products and their distribution. Two people were interviewed, one is in charge of transport and environment and the second is the head of the department of electronic media.

In general, both pointed out that the Internet channel performs better than the traditional channel in all the individual firms; while the growth rates are rather small in the traditional channel, some shift to the Internet can be observed, though it is difficult to be precise because many of the customers are multi-channel purchasers; however, most of the new customers (also) use the Internet. From the company's perspective, the new channel is in the focus to bring economic as well as ecological advantages.

The customers of the mail-order company not only represent rural and remote regions, but also families with children. Usually Internet customers are mostly male, but the mail-order company's customers tend towards the traditional gender balance, where two out of three customers are female. In general, Internet customers are better educated, have a higher income and are younger than the average. Referring to the items sold, the Internet is better at selling so-called "hard goods", with a focus on multimedia, and not textiles, which still benefit from printed catalogues. However, the potential for the Internet is thought to be very positive, in this area as well. The number of items per order is a little below the traditional channel, but does not tend to really small orders, maybe because of the global fee per order.

The handling of the orders and delivery is about the same for the traditional mail-order channel and for the Internet-based distribution. **Therefore, no significant changes are seen in transport demand.** After the input of the information in the systems the storage centres are informed and individualise the items to the respective customers; after overnight delivery to the 65 regional deposits, the distribution is conducted. The individual drivers are provided with computer-based route recommendations. Three attempts at delivery are standard.

Particular advantages of the Internet-channel are seen in (a) cost-saving from automatic input of the orders, (b) detailed information on delivery for the customer by e-mail or phone, (c) customer's option to follow the actual status of delivery using an individual code, (d) optimisation of the financial transactions and their documentation.

Box 5-2: Interview with large company trading office supplies

The company interviewed is a multinational trading company offering a wide assortment of office supplies. The Marketing Manager for Europe was interviewed.

The company offers the use of three different channels: a number of chain stores (60 in Germany), catalogue-based ordering, and the internet-based market channels. The range of goods offered is largest on the internet, totalling 10,000, compared to 5,000 in the catalogue and 7,500 in the stores. In contrast to the company whose interview is presented above, the catalogue and the Internet-channels are restricted to business customers with, in Germany, a focus on small- and medium-sized enterprises (the U.S. homepage also refers to the Fortune 500).

Special characteristics of the Internet customers compared to the catalogue-based buyer include: higher rates of re-buying, higher buying frequencies, higher average order value, mostly young enterprises from the service sector, usually located in urban agglomerations. A particular advantage of the Internet channel is seen in the functionality and in the higher speed (faster than catalogue-based orders). Interestingly, the volume of orders peeks at noon and is also high between 19:00 to 21:00 o'clock.

The logistic chain from the central store in Belgium to the single customer is not very different from the one described above. Again, as a consequence, no significant differences in transport demand are noticed between catalogue-based and Internet-based distribution.

5.2.2 Analysis of shopping travel at the macro level

For the integration into an overall picture, the development of shopping travel in Germany from 1991 to 2000 was analysed. The detailed data is contained in Appendix 3, attached to the case study on telework within the Digital Europe project. Here, only headline results are presented.

In the year 2000, in Germany[99] 25.9 per cent of all trips were shopping trips, accounting for 8.8 per cent of the distance travelled. The relatively small share of distance travelled results from the modal distribution; every second trip for shopping consists of a walk or a bicycle ride, which show significantly shorter mean distances than trips using a motor vehicle. For Sweden, 2000, Arnfalk[100] reports a share of 7 per cent for shopping, on the distance travelled; an additional share of one per cent is reported for health care, included in shopping in the German data. The Swedish data does not cover walking and cycling, which in total – not only for shopping - are reported to cover 2.7 per cent of the distance travelled. The data from the British

[99] Kloas, Jutta & Kuhfeld, Hartmut. (2002): Stagnation des Personenverkehrs in Deutschland, in: DIW-Wochenbericht 42/02 (Stagnation of Passenger Transport in Germany, in: Weeekly Reports 42/2002 from the German Institute for Economic Research), Berlin.

[100] Arnfalk, Peter (2002): Virtual Mobility and Pollution Prevention, Lund. Figures based on Jönson, Gunilla & Johnsson, Mats (2001). Electronic commerce and distribution systems. Lund Institute of Technology.

National Travel Survey[101], 1997/99 Update, indicates shares of 21.1 per cent of the trips devoted to shopping, and 13.0 per cent of the distance travelled, respectively; because the British data in general does not cover the full length of air travel, also these figures refer to the same range of shopping within the overall transport.

The time series for Germany shows a nearly constant number of 300 shopping trips per person per year. The distances travelled per capita grow slowly, due to modest shifts from non-motorised to motorised modes of transportation. At about 1,400 km per person and year, the saturation point may have been reached. In 2000, the last reported year, a distinct reduction occurred particularly in the distance travelled, probably because of the fuel price disturbances, as the reduction completely originates from reduced car use.

Reductions in shopping travel as a consequence of teleshopping could not be observed in the overall picture. But naturally the possibility that teleshopping was generating marginal effects should not be ruled out.

5.2.3 Perspectives

The future perspectives appear clear and unclear at the same time. Clear on the one hand is the growing importance of the Internet as a part of the purchasing process, providing an additional channel through which to purchase goods, or just additional features within the process. Within the different possibilities, any of them may be realised individually, as long as seems advantageous. In some cases, for example, the Internet may be used to provide information on products and services, which are then purchased in traditional stores. The reverse is also possible, whereby, customers become familiar with a product or service in a shop and then purchase the good via the Internet.

This is the basis of an unclear picture referring to the transport consequences. Some markets, typically rather small ones, may fall to the Internet channel, other markets will split between the channels. But how many shopping trips and kilometres travelled will this influence? The answer until now has been: not too many. Apart from groups of society with limited mobility such as certain handicapped people and some of the elderly, and those living in remote areas there has not been a significant take up of online buying. That is to say, for those for whom it is relatively easy to go shopping, shopping online has not proved to be an especially attractive option and shows no signs of doing so.

Our analysis did not give a clear indication as to whether B2C ecommerce will contribute to the so-called decline of the European city. However it did give reasons to believe that teleshopping will tend to reduce transport use more than it generates it.

5.3 Transport and Telework

Home-based telework, teleconferencing, mobile computing and further specific models form the big issue of telework, by which the traditional shape of work is likely to be changed fundamentally. Initially, more precise definitions of telework will be

[101] Department for Transport, Local Government and the Regions (2000): Transport Statistics Bulletin: National Travel Survey: 1997/99 Update, London 2000.

need to get an idea of the transport consequences. The various kinds of telework shall be characterised in a second step.

For general transport aspects we refer here to the respective chapters of the case study on telework. General aspects of transport savings, additional benefits, travel time and the kinds of potential rebound effects are briefly described there. In addition, essential information can be found for the calculation of transport effects.

Finally, some calculations on the potential effects are given, for the moment in quite a rough manner and only for (home-based) telework.

5.3.1 Definition of telework

The definitions of telework are many and varied. Research conducted by the Technical University of Hamburg-Harburg[102] identified several dozen definitions for the term telework in Germany alone. The European Commission[103] defines telework or ework as:

“a method of organising and/or performing work in which a considerable proportion of an employee’s working time is: away from the firm’s premises or where the output is delivered; and when work is done using information technology and technology for data transmission, in particular the Internet.”.

Telework has two essential characteristics:

- Work that is carried out away from the designated place of work
- The change in location is made possible by the use of modern ICT

Work has always taken place in a variety of locations, from production plants and government offices to private homes and coffee shops. Any discussion of telework must differentiate between such types of work and new working patterns and locations which have been brought about by information and communications technologies (ICT). From a transport and social perspective, it is the change of location that is important rather than the use of ICT. Therefore, the use of ICT as a new work tool should only be defined as telework where there is an accompanying change in the location of work.

Figure 5-5 shows primary work locations and the main opportunities for shifts in work location. (note: telecentres are special units for ICT-based telework which are not under the control of one specific firm, but are used by employees from different enterprises).

[102] Nerlich, Mark. (2001). Tabellenband der Telemobilitätsstudie 2001 (volume: tables of the study “telemobility”), Hamburg-Harburg.

[103] European Commission (2001). Status Report on New Ways to Work in the Knowledge Economy, available online: http://eto.org.uk.

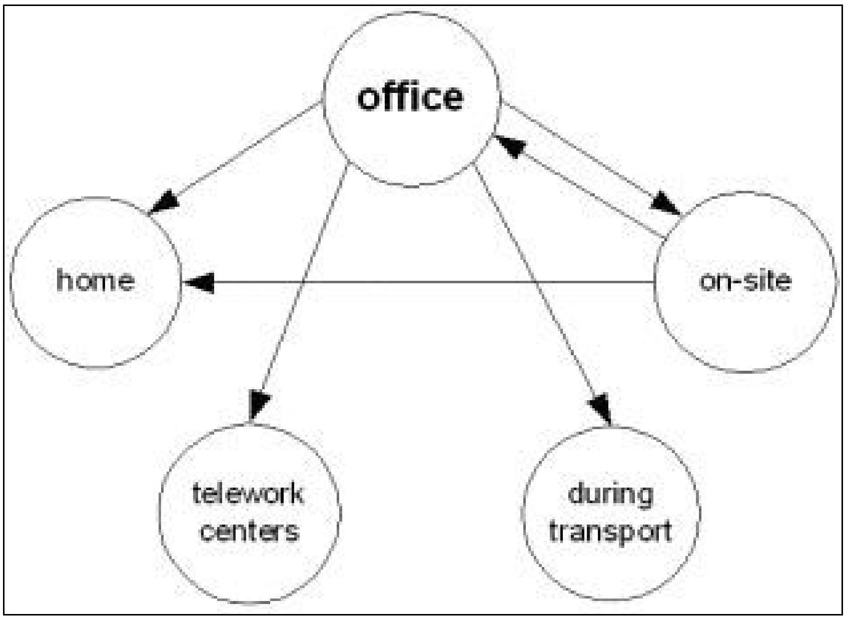


Figure 5-2: Main areas for potential spatial work shifts (Source: Wuppertal Institute).

In addition, if ICT is used to a very limited extent and on a more or less occasional basis, this activity would not be included in the definition of regular telework. Similarly, ICT applications which contribute only marginally to work flow would not be included. On the other hand, if possible access to a particular ICT service is limited but decisive in enabling telework, this should be included.

Some difficulties arise in relation to the use of telecommunications. Of course, the telephone was established long before the term ICT became widely used. Technological innovation has been a constant feature of the telecommunications sector. Mechanical components were replaced by electronic components at the central switching centres, the telecopy technologies evolved, etc. In this context, it may seem unconvincing to set the development of mobile telecommunications apart from earlier innovations. Opinion may change, bearing in mind the likely range of future services.

However, it should be mentioned that there are different definitions in use, including those by ECaTT, which are shown in the following table.

Table 5-1: ECaTT definitions of different kinds of telework[104].

Organisational form	Definition	Operationalisation in ECaTT
home-based telework	teleworkplace is situated in the living environment of the employee	working at home, using telephone, fax and computer; excluding those who do not work at home for at least one full day per week
included: permanent work	telework in the stricter sense: form of home-based telework where work is constantly carried out in the home	those home-based teleworkers who practise telework for at least 90 per cent of their working time
included: alternating telework	work at home alternates with presence in a central office	those home-based teleworkers who practise telework for less than 90 per cent of their working time (but on at least one full working day per week, see above)
mobile telework	frequent business travel using information and communication technology at a temporary or mobile workplace	derived from answers to: 1) out and about for 10 or more hours per week, 2) using online links while travelling
Small office/home office (SOHO)	telework of self-employed whose main workplace is their office at home	derived from answers to: 1) self-employed (or those who have extensive management powers), 2) working from home (or do not have a central workplace), 3) communicate with external contacts via e-mail, file transfer, shared databases or videoconferencing
additional: supplementary telework	*home-based telework which is exclusively carried out in addition to work in the office workplace*	*those who say they practise telework but do so for less than 1 working day per week*

The “ECaTT-definitions” in particular show two differences compared to our basic definitions of telework from a transport perspective. First of all, ECaTT has a clear focus on home-based work, which is not the case in our more general definition. As a result, teleconferences and several other forms are not covered by the ECaTT-definitions (and the results presented by ECaTT). Secondly, the validity seems rather weak in ECaTT`s definition of mobile telework. As a matter of fact, defining clear limits to mobile telework is problematic, but the definition given by ECaTT does not bear close inspection as it does not account for how much and how intensively mobile teleworkers are involved in mobile telework.

[104] Empirica GmbH (2000). Telework data report (population survey) - ten countries in comparison -, Bonn, op.cit. p. 9.

5.3.2 Home-based telework: Experience until now

Spread of home-based telework

Referring to the ECaTT survey, the spread of regular telework in Europe can be estimated at about 5 per cent of the complete labour force. Penetration differs between countries, being high in the Scandinavian countries and the Netherlands, medium in the UK and in Germany, and lower in southern Europe and Ireland. Selected case studies show a broad range, with a large number of examples recording few people teleworking and a few examples in which several hundred people are teleworking.

Various studies from the U.S., the Netherlands, the UK and Germany[105] report that the average commuting distance of teleworkers is significantly above the regional mean for employed persons. According to these studies, the average weekly working time at home is about 1.5 days. The findings regarding various rebound effects partly do not match. As a result, savings in distance travelled per employee are estimated to be around 2,000 to 2,500 kilometres annually.

However, the results of the studies may not be very representative of society as a whole because, by and large, the studies only analysed small numbers of samples and the composition of the samples did not follow regular probabilistic sampling methods. Nevertheless, some studies claim to give evidence of significant transport savings. For example, the German study shows a reduction of the overall commuting distance of roughly one per cent in 1999.

Overall analysis of commuting

As for shopping, the evolution of commuting within the last ten years was analysed using macro data.[106] According to German data for 2000[107], commuting to work represented a share of 19.5 per cent of all trips, and of 16.5 per cent of the distance travelled. The 2000 data for Sweden, reported by Arnfalk,[108] shows that work and study commuter travel accounts for 21 per cent of trips (excluding non motorised modes of transport) and 2.7 per cent of distance travelled. The 1997/99 Update of Great Britain's National Travel Survey[109] found that commuting made up 15.7 per cent of all trips and 19.5 of all distance travelled. Because of the non-coverage of most distance travelled by air in the British survey, the distance travelled for

[105] shown in: Walter Vogt, Stefan Denzinger et al. (2001): Auswirkungen neuer Arbeitskonzepte und insbesondere von Telearbeit auf das Verkehrsverhalten (effects of new concepts of work, and in particular of telework on travel behaviour), Bremerhaven 2001, pp.103.

[106] for the details cf. APPENDIX 3 of the case study on Telework within the Digital Europe project.

[107] mainly based on: Kloas, Jutta & Kuhfeld, Hartmut. (2002): Stagnation des Personenverkehrs in Deutschland, in: DIW-Wochenbericht 42/02 (Stagnation of Passenger Transport in Germany, in: Weeekly Reports 42/2002 from the German Institute for Economic Research), Berlin.

[108] Arnfalk, Peter (2002): Virtual Mobility and Pollution Prevention, Lund, p. 46 in reference to: Jonsson, J. (2001): Statistical data for passenger transport in Sweden 2000.

[109] Department for Transport, Local Government and the Regions (2000): Transport Statistics Bulletin: National Travel Survey: 1997/99 Update, London 2000.

commuting matches with the German figures despite the higher shares named for Britain. In the light of this, the low number of commuting trips in Great Britain (164 per person and year) seems a little astonishing. Both, German and British figures do not cover educational trips, unlike the Swedish data.

The time series for Germany[110] shows a nearly constant number of 500 commuting trips per employed person and per year, though the number of working hours per employee decreases steadily. Therefore, the work-time specific distances travelled have grown fairly continuously by 10 per cent, reaching now about 4 km per working hour (about 5,600 km per employee). The slight growth in mean distances fits with the low shares of non motorised modes, slowly shrinking in favour of car drivers' trips. A marginal reduction of the work-time specific trips and distance travelled by 0.8 per cent in 2000 after the maximum in 1999 represents the reaction to the fuel price escalation within the last reported year, predictably the figures shows less elasticity than those for shopping or leisure trips.

Reductions in commuter travel as a consequence of telework could not be observed in the overall picture. Clearly, there will be some reduction due to saved commuter trips. However significant positive effect will not appear until a reduction in working hours is followed by a reduced number of commuter trips, which is the opposite of what the data now shows.

5.3.3 Future Trends

Potential spread of telework

Guessing the future trends of telework should not be too difficult. The future demands for technical infrastructure are relatively predictable and in the meantime technical infrastructure represents a bottleneck only in rare cases. Future trends will, therefore, mainly depend on the working conditions of the employed people.

Calculations of the potential numbers of teleworkers had to be based on grouping employees into professional groups. Evidently the kind of work conducted determines whether the work can be carried out using ICT-installations at home and the Internet and to what extent.

Unfortunately, most employment statistics do not focus on the professions of the workers, but on the industry groups in which they are employed. Calculations are therefore based on German data, where breakdowns by professional groups are available. Comparing the breakdown by industry codes between different countries confirmed that the German data could serve as a proxy for the rest of Europe, though differences between the countries do exist. As an example the shares for the labour-force working in the sectors of agriculture, horticulture, fishing etc. vary significantly, but represent minor portions anyway.

The 1992 edition of the German classification of professional groups divides the labour force into roughly 100 professional groups. Thereof the groups 60-61, 64, 67-69, 75-78, 82 and 88 would be able to telelwork. The respective figures of employed

[110] mainly based on Kloas, Jutta & Kuhfeld, Hartmut. (2002): Stagnation des Personenverkehrs in Deutschland, in: DIW-Wochenbericht 42/02 (Stagnation of Passenger Transport in Germany, in: Weeekly Reports 42/2002 from the German Institute for Economic Research), Berlin.

persons are reported in the table 5-3. (While the numbers are based on the official statistics[111], the English nomenclature is not official, but results from a quick translation). Together the relevant groups respresent about 30 to 35 per cent of all employed persons.

Table 5-2: employed persons by selected professional groups in 1000, Germany, April 2001 (table extract of relevant professional groups[112].

No.	professional group	total	male	female
60	engineers	979	878	101
61	analytical chemists, physicists, mathematicians	100	82	27
64	researcher and similar professions	126	49	77
67	mercantile professions (not including shopkeepers)	1,066	557	508
68	salesmen	339	216	123
69	employees within the banking & insurance sectors	930	464	466
75	managing, consulting and controlling personnel	1,494	1,043	452
76	representatives, administrative personnel	315	192	123
77	accountants, computer scientists	1,195	615	580
78	office personnel, assisting personnel	4,576	1,226	3,349
82	writers and translators	217	101	117
88	scientific professions	301	180	121
	selected professions	11,638	5,603	6,044
	all professions	36,816	20,629	16,187
	share of selected professions by per cent	*31.61*	*27.16*	*37.34*

In some cases such employees or even complete working groups may shift almost all their work to private homes or to SoHos. Probably only a certain portion of them will shift shares of their work. For calculation needs, one can presuppose that about 75 to 80 per cent of telework-capable employees have some kind of teleworkable working conditions. This assumption is supported by the figures provided by Postel-Vinay[113] for France. The ECaTT-survey gives a far higher estimation, calculating that potential teleworkers make up two thirds of the total labour force. The high estimation is a consequence of the criterion used in the ECaTT survey, which classifies work that can be teleworked as any work where at least six hours per week is conducted at a desk. It does not seem very realistic to base the potentials for regular telework on this criterion. However it does give a hint as to the potential for sporadic home-based telework.

[111] Statistisches Bundesamt (Federal Statistical Office, Germany): *Statistisches Jahrbuch 2002* (statistical yearbook 2002) p. 107.

[112] Statistisches Bundesamt (Federal Statistical Office, Germany) Statistisches Jahrbuch 2002 (statistical yearbook 2002) p. 107.

[113] Postel-Vinay, Gregoire (2002): Can telework save energy? A French outlook, paper presented at the IEA-conference ”The Future Impact of Information and Communication Technologies on the Energy System”, Paris, February 21-22, 2002; presentation available over the IEA-homepage.

Modelling potential transport savings without rebound-effects

We will now turn to an assessment of the future potential for transport savings generated by home-based telework. As a best case it may be assumed, that home-based telework will normally consist of complete working days at home, and rebound effects need not be considered. Obviously under such conditions commuting could be reduced to a significant extent. The calculation in table 5-4 is based on the current situation of labour and of transport. Future changes in the labour force, including the disappearance of certain professions as well as the creation of new ones, are not reflected. Likewise potential changes in travel habits are ignored, which will alter the balance of transport and the shares of total travel accounted for by the various reasons to travel.

Table 5-3: Future potential for transport savings by home-based telework: Best case (Source: Wuppertal Institute).

Group	Definition	Object	Shares of total distance travelled
All employed persons		commuting	16,5 per cent
telework-capable jobs	32 per cent of all employees	their commuting	5,3 per cent
home-based teleworker	75 per cent of employees with telework-capable jobs	their commuting	4,0 per cent
telework days at home	40 per cent of the working days	saved commuting	1,6 per cent

As recent studies make clear for Germany, commuting makes up about a sixth of all passenger kilometres travelled. Regional differences may exist, but will not be very high across the EU. Significantly higher shares reported in other studies typically result from ignoring relevant shares of all passenger kilometres travelled when calculating the 100 per cent basis, in particular from excluding parts or all of the air travel.

The share of telework-capable jobs is discussed above and estimated at nearly 32 per cent of all jobs. Again, an appropriate data base for the EU was not available because other data groups employees by the type of industry they are working for rather than by their professional skills. As a consequence, a comprehensive survey of the job characteristics of European employees may result in minor corrections. As long as a systematic and relevant difference between the average commuting distance of the telework-capable workers and all employed persons can not be seen, the commuting travel of telework-capable employees corresponds to their share of the complete labour force. Therefore about 5.3 per cent of all passenger kilometres travelled fall to the share of their commuting.

It is estimated that three-quarters of those with telework-capable jobs might telework from their homes on a regular basis (i.e. for one complete day per week.) This corresponds to roughly one quarter of all employed persons. Whilst in an early phase of home-based telework the commuting distances of teleworkers may be significantly above the average, as reported in several studies, this effect should disappear, as home-based telework becomes more widespread. When telework is more widespread distances should be about the same as for other employed people. As a consequence, the hypothetical commuting distances travelled by the home-based teleworkers might equal 4 per cent of all passenger kilometres travelled, presuming that they will travel in to the office several days per week.

As a further estimation, the share of home-based telework days can be assessed at about 40 per cent of all working days, or two days per week on average. This estimation for instance corresponds to distributions of teleworking like 40 per cent of the teleworkers with 1 day/week, 50 per cent with 2.5 days/week, 10 per cent with 4 days/week working home-based, or 40 per cent with 1 and with 2 days/week each, and 20 per cent with 4 days/week working home-based. Without being too precise, distributions like this seem to mark plausible ranges. To conclude, the portion of commuting that is avoided because of home-based telework represents about 1.6 per cent of all passenger kilometres travelled.

When rating the results we should bear in mind, that the calculation is rough as well as robust. However, by excluding any rebound effects the picture is to be rated as a rather optimistic view. It may be worth mentioning that a reorganisation of working times so that on average 4 instead of 5 days per week were worked would result in commuter travel savings of twice as much.

Modelling consequences of potential rebound effects

Recently, studies by Schafer and Victor from MIT, Boston, confirm several general findings in passenger transport[114:]

The average daily travel time of individuals is a near-constant value, widely the same all over the world and over long historical periods, at about seventy-five minutes. (Hypothesis on the constant travel time-budget)

The average travel cost of individuals represents a near-constant share of their overall budget, widely the same all over the world and over long historical periods, at about 15 per cent of the total. (Hypothesis on the constant travel money-budget share).

As a result, the distances travelled are growing by a growing use of faster modes of transport substituting slower ones, according to growing income and/or relatively sinking travel costs.

These findings, backed up by national empirical results[115], now appear to be recognised on a global scale, and lead to questions concerning non-systemic approaches to transport saving. Given the idea of constant travel time-budgets and constant travel money-budget shares, transport saving will tend to be counterbalanced somehow.

[114] Schafer, A. MIT Center for Technology, Policy & Industrial Development, and MIT Joint Program on the Science and Policy of Global Change: Modeling Global Mobility – World Passenger Transport Through 2050. Presentation at the Transportation Vision 2050 Futurist Workshop, Doubletree Inn at Southcenter Mall, Seattle 2000, Sheet 6; cf also SCHAFER, A. / VICTOR, D. (2000): The Future Mobility of the World Population. Transportation Research A, 34 (3), pp. 171 – 205.

[115] Schallaböck, K.O. (1996). Verkehr und Zeit (travel and time), in: Jürgen P. Rinderspacher: Zeit für die Umwelt (time for the environment), Berlin 1996, pp. 175 – 212.

Additionally, other rebound effects are discussed, though the empirical proof is poor, showing different results in different surveys. These effects may include:

- Telework, as a further consequence, may contribute to more widespread and sparsely populated settlement patterns. Greater distances between settlements may generate additional social costs and, for the transport sector in particular, reduce the potential for public and non-motorised transport.

- Further disadvantages may result from changes to daily commuting routines. In several cases, established car-sharing/car-pooling schemes report efficiency losses. However overall, the impact will be minimal given that the current occupancy of passenger cars for commuting purposes according to German figures is just over one person per car. Locally, the experience may differ, but this cannot be generalised.

- Rebound effects may result from varied patterns of work management when working at home. This could lead to additional trips which would not be made when working from the office. Furthermore, additional trips may be required to complete tasks previously completed as part of the daily commute.

- Finally, family members (and others) are able to use the car on days when the teleworker is at home. This may reduce the need for a second or third family car, but could stimulate additional car-use.

For a worst case model the hypothesis of constant travel times was chosen as a basis, while neglecting other rebound effects. This, at first glance, would compensate for the transport savings. Indeed, even an overcompensation will be plausible, due to sinking marginal cost and growing marginal speed of transport: Three trips of 20 minutes each will normally cover a shorter distance than one trip of 60 minutes. Estimating the quantitative effects on the average distance travelled is a little bit fuzzy. Model calculations carried out for the telework case study came to potential additions of about 1.4 to 2.5 per cent of all passenger kilometres travelled. The results will be strongly influenced by the portion of teleworkers who accept very long commuting distances as a consequence of relatively rare visits to the office, e.g. two days per fortnight, and by the respective means of transportation used. If going to the traditional working place in the office just two times per month, with an overnight stay there, why nor remain living in Milan or Madrid, when working in Manchester. Obviously, such cases are not likely to represent significant shares of all employees in a telework future, but they may contribute noticeably to the commuting distances travelled.

5.3.4 Mobile telework

While telework and teleconferencing reduce travel and time spent travelling, mobile computing allows for better use of remaining travelling time.[116] Thanks to ICT, travelling time need not be time lost. In reality, there are limitations to mobile

---

[116] The term ”travel time“ is not always used in a uniform sense. In the field of transportation, travel time normally denominates the time needed to move from one to the other place, including necessary breaks if need be. Other concepts not preferred in the study here cover the full travel from the starting point until the return. As a result, the idea of mobile teleworking focusses more on the use of ICT during the change of place.

working. Commuting by car leaves little opportunity for the use of mobile computing at the same time. On public transport, the possibilities are greater but there are limitations: waiting for a train, changing trains, standing on a local train or even sitting on a bus provide little opportunity for concentrated computer work. Nevertheless cellular phones and other handheld devices can easily be used, and the use of full-scale computing is increasingly possible for long-distance passengers. When and how the strict restrictions on ICT use imposed on many flights will be relaxed remains unclear, but the point is on the agenda. Carriers have already started tests on ways not only to facilitate the use of laptop computers, but also to give access to the world wide web on selected flight.

The extended working options are evident for small groups with high travel intensities like travelling salesmen, reporters, or managers in business, policy or science. The consequences on the labour force as a whole are hard to determine. However we suggest that the general impact is to expand travel activities by adding supplementary advantages to travelling. On an individual basis, the effects may be quite significant as trips of longer duration benefit from additional working capacities.

5.3.5 Teleconferencing

Avoiding travel by using teleconferencing has been a stimulating idea for a long time. Arnfalk gives a survey of many studies since 1978,[117] claiming substitution potentials of up to 40 per cent of business travel. Also, the respondents to several questionnaires generally say that teleconferencing has, in most cases, replaced physical travel. These findings are supported by the results from the industry partners of the Digital Europe telework case study. Only a small portion of teleconferences is said to be additional to or to increase business travel activities, maybe one out of four or five teleconferences.

Macro data analysis for Germany 1991 – 2000, on the other hand, shows[118] that business travel represents the fastest growing segment of passenger transport (together with vacation trips). Including the full distances of air travel, business trips may contribute to about a quarter of all passenger kilometres travelled, representing growth rates in distance travelled at about three per cent annually.

Therefore, teleconferencing is not that promising for the environment, contrary to what some studies suggest. The general impression gives rather clear evidence that the currently extended facilities of ICT have stimulated more intensive business relations over an expanded geographical range thus generating additional travel, while the respective communication technologies have substituted several trips at the same time, reducing the net growth of travel a certain amount.

5.4 Conclusions

Modern and forthcoming ICT obviously can create transport savings, either by substitution of physical transport or by the more sophisticated organisation of transport. ICT's potential to generate transport savings should not be overestimated.

---

[117] Arnfalk, Peter. (2002). Virtual Mobility and Pollution Preventing, Lund University 2002, p. 54.

[118] for the details cf. APPENDIX 3 of the case study on Telework within the Digital Europe project.

Whether it will lead to transport savings may depend on a range of framework conditions. For e-business analysed in this study, the main results include:

Teleshopping (B2C) only has the potential to generate small transport savings. This is because shopping travel represents only a small portion of the overall distances travelled, teleshopping generates additional delivery transports, bigger potential for additional transport due to possible compensating passenger transport and rebound effects.

Home-based telework offers relatively clear possibilities for small transport savings (up to about 1.6%) as well as for small additional transport (up to about 2.5% of passenger kilometres travelled, based on present transport activity), depending on rebound effects.

Mobile telework appears to generally stimulate transport by increasing the acceptance of trips with longer duration. The transport savings generated by mobile telework are difficult to determine quantitatively.

Teleconferencing provides a relatively high theoretical potential for transport savings. The savings can be up to about 10% of passenger kilometres travelled, based on present transport activity. However, it is more likely that teleconferencing stimulates additional transport but it is hard to quantify how much.

Practical experience will cover a broad range in any of the fields due to the individual conditions. This will include a variety of examples, but they may not become generalised.

Looking to the future, the outcome may follow different paths. On the one hand, the spread of any of the e-services will depend on their cost and comfort. It is highly likely that a continuation of the present trend will lead to significantly widespread use. On the other hand, transport habits will largely depend on cost and speed of transport; as long as costs continue to fall (in relation to average income) and speed continues to increase (especially by the availability of cheap air transport), reducing the distances travelled is not a very likely possibility.

6 Recommendations for Policy and Business

The conclusion of the analytical work within the Digital Europe project was that ebusiness activities are far from purely virtual but strongly linked to the use of natural resources. However, negative environmental effects caused by a structural change from "old" industry towards an e-economy could not be observed at the macro level. Key factors for improvements in resource and transport efficiency have been identified through systems-wide assessments. This section makes recommendations, targetted at the business and policy community, on how to maximise ebusiness' potential to dematerialise.

Drawing on the case study research, a number of specific recommendations have been made and presented in the case study reports on mobile computing, digital music, ebanking and telework. For the theme report, the recommendations focus on a more aggregated level (ebusiness, egovernment and ICT sector). Therefore, the recommendations given below are of a more general nature and refer partly back to case specifics.

6.1 Monitoring the environmental Impacts of ICT and Ebusiness

The quantification of environmental effects caused by new technologies is still a major challenge. This is partly based on the fact that the availability of relevant data in such new fields is low. However, specific information is needed for better decision-making. Regarding the effects of ICT on resource consumption and transport intensity, monitoring should be improved at different levels.

At **policy level,** the provision of adequate statistical information is important, for instance, by the annual synthesis reports based on a set of structural indicators, and the thorough analysis and assessment of this information is crucial for the Lisbon policy process. In particular, the macro-economic technology pattern, with relation to labour, resource and capital productivity, should be carefully monitored in order to detect unwanted developments like the increase in resource consumption in the ICT sector. Also, enhanced transport statistics for the European Union are needed, covering all means of transportation (including the non-motorised modes), and all sections of travel (including the air travel sections outside national European territories).

At a **business level**, particularly for ICT product and service providers, the integration of economic and environmental information systems through a combination of cost accounting systems with material flow data (material flow accounting) should be promoted. By combining data on costs of material and energy flows with information on material intensities (the ecological backpacks), areas for potential environmental improvement, as well as for cost reductions, can be identified. Of particular importance in the ICT sector is the inclusion of the supply chain, which means taking into account the ecological costs of preliminary production and transport. Assessments of ICT products' environmental relevance are hindered by the lack of relevant information on their production, use and end-of-life phases. Providing and disseminating this kind of information, at the business level, will help to find improvement options.

Regarding environmental assessments within the fast moving ICT sector, **scientific methodologies and approaches**, which allow the indirect effects of ICT to be "measured" and investigated, i.e. how far ICT enables innovation (in particular eco-efficient innovations), should be further developed. Further efforts are required to improve macro-level statistical classification systems so that they better reflect ICT-related businesses. Scientific support is needed for the establishing of integrated environmental and economic information systems allowing combined socio-economic and environmental analyses at the macro-economic level.

6.2 Greening ICT hardware

Research within Digital Europe revealed how significant a factor ICT infrastructure is in the resource consumption of ebusiness and egovernment. Along with the resource intensive production of ICT devices, the electricity consumption during the use phase contributes significantly to the overall material intensity. Thus, it is necessary to promote more resource-efficient electricity generation and more resource-efficient ICT infrastructure.

Considering the increasing spread of ICT in Europe and its complex environmental effects on different levels, the precautionary principle demands a **timely development of policy action**. The technologies for Internet access and ebusiness in general are quickly outdated and their production constitutes a high share of their environmental backpack. Thus, the extension of the lifetime is an optional way to reduce resource consumption. Also, the shared use of ICT equipment might reduce the number of ICT devices needed. Here, voluntary actions, such as design for environment or extended warranties, initiated by proactive ICT companies should be promoted. Additionally, public procurement could include environmental criteria such as standby power consumption and resource efficiency in purchasing guidelines.

At the policy level, initiatives and activities concerning renewable energies in the ICT sector have to be promoted in the future. In order to achieve the goal of doubling the share of renewable energies by 2010, a mix of measures will be necessary to promote the use of renewable energy by ICT, e.g. technology for solar panels. Governments can also contribute to moving the market from a demand side. Criteria and incentives for a green(er), less material intensive power supply should be included in authorities' procurement guidelines for ICT equipment. As a complementary measure, targets for continuously increasing the share of renewables could be set and reported on on a regular basis. An increase in renewable energies would also contribute to reaching the goals of the Kyoto Protocol.

For decision-makers in business, it is important to consider the system-wide effects of ICT and ICT applications. Even though there might be situations where ICT enables the saving of natural resources or transport at a specific life-cycle stage, the opportunities should be evaluated regarding their system-wide effects. Often, the early manufacturing stages and the use phase are not given sufficient attention and these phases turn out to be very significant for a large number of ICT products and services, in particular ebusiness applications, flat rates and always-on connections which are increasingly used. Digital Europe's research pointed out that significant material intensity is connected with it. Consideration of how to minimise these effects should already be included in the design phase of products and services. For example, incentives for users or technical solutions to disconnect from the web, to switch on sleep modes and to disconnect charging devices can be built into the design of devices. With regard to potential rebound effects, business is asked to innovate technologies which can be handled in accordance with (existing) consumer habits, rather than the consumer having to adapt to the technology.[119]

What has been said on the procurement of green(er) electricity and ICT equipment is of course applicable to *business* as well. Procurement guidelines and environmental management systems should emphasise these issues. Related targets for continuous improvement should be set as well as communicated. However, it is not only a question of green(er) energy or green(er) ICT devices, but also of efficient usage. That energy-related material flows make up so significant a portion of the total material flow for these technologies suggests that there is still potential for environmental and economic gains.

Regarding the end-of-life management of ICT, the adoption of the EU's **waste electrical and electronic equipment** (WEEE) and substance restrictions (RoHS) directive in October 2002, has changed the situation for ICT firms. Now, they are more encouraged to tackle electroscrap recycling. However, a successful and efficient end-of-life treatment will only be achieved if ICT manufacturers bear individual responsibility for their goods. Such a responsibility would trigger the eco-design improvements necessary to reduce the environmental effects of devices. Voluntary initiatives, such as the cooperation of leading mobile phone manufacturers with the Basle Convention[120], are promising steps towards a reduction in the environmental effects of mobile devices. Additionally, other major efficiency improvement obstacles, such as the lack of communication along the supply chain, need to be overcome. Knowledge about the environmental effects along the entire product chain is a necessary precondition to the identification of efficient improvement options. Thus, the incorporation of network operators and other important stakeholders into a dialogue on improvement options is highly advisable.

Considering the complexity of ICT product systems, researching their environmental impacts is a major challenge. Due to the complexity, **more systemic evaluations** of the environmental consequences of computing devices are needed in the future. To identify the resource and energy efficiency opportunities of computing equipment, it is necessary to take a holistic approach and to consider the entire communication system, user habits and the social aspects of communication. Future evaluations should be based on methods that integrate quantitative research to evaluate environmental effects with qualitative research that analyses consumer demands and behaviour.

6.3 Shifting to eservices

As pointed out in the conclusions, ecommerce can – under certain circumstances – allow significant resource efficiency gains, especially if physical products are

[119] Epaper solutions, portable, reusable storage and display medium that looks like paper but can be repeatedly written on (refreshed) by electronic means, might prove to be one of the first commercially successful examples..

[120] UNEP. (2002): Leading Manufacturers And Basel Convention To Cooperate On The Environmentally Sound Managment Of End-of-life Mobile Phones. [Online] Available: http://www.unep.org/Documents/Default.asp?ArticleID=3189&DocumentID=274 [18 December 2002].

replaced by eservices and provided that they are not re-materialised later on. At different levels resource-efficient e-services and their framework conditions can be promoted.

At the policy level, the shift towards eservices can be supported in different ways. Obviously public administration can be a forerunner by offering eservices as part of their egovernment strategies. As well as being a provider of eservices (push-strategy), authorities could request services instead of products from their suppliers wherever possible (pull-strategy). One simple example would be the renting of copying services instead of buying copying machines. In so doing they will meet the challenge of avoiding rebound effects within their organisations (see also next section). Another area of improvement is the societal and technological framework conditions for the uptake of eservice applications. Fast, affordable and reliable Internet connections are a prerequisite, as is trust in the confidentiality of data transferred via the net. Besides this, large parts of the population still lack basic esociety literacy. Empowering these groups is a key to wider uptake of eservices.

For business, the shift from products to eservices offers a number of advantages. These include not only the opening of new markets and closer customer relations, but also the reduction of costs. Cost savings will result from lower material inputs and thus help to decouple growth from material turnover. The case study on banking has proven that e-applications such as online banking can be more resource efficient than their traditional counterparts. If eservices are used as additional sales channels, reductions in the traditional channels should be made, e.g. savings of office space used. Otherwise eservices can promote additional resource consumption.

The **scientific research** pointed out that for some products, especially those that can be reduced to an informational core (e.g. music or financial products) there is a the potential for dematerialisation. This potential is, however, small when compared to the resource use at the macro level. Scientists should carry out assessments to determine in which sectors (of traditional industry with high resource consumption) the use of ICT can enable a dematerialisation noticeable at the macro scale. Such an assessment would help to determine where it would be worthwhile promoting eservices on a larger scale.

6.4 Enabling transport efficiencies

This section gives recommendations drawn from the analysis of telework regarding transport efficiency (see also case study on telework). Transport-related findings from the B2C case studies have also been considered for these recommendations. They focus on the provision of a sound information base, the potential advantages of telework, and the option for reducing or mitigating rebound effects.

A more balanced view of the opportunities and risks of telework and teleconferencing needs to be adopted. We need to learn to make more balanced judgements of the implications of ICT than we did ten years ago. **At the policy level**, one way of promoting telework and teleconferencing while at the same time mitigating the unwanted rebound effects would be to review speed limits. Reducing the speed of physical transport would tackle one important steering parameter for the negative side-effects of transport and stimulate the usage of telework and teleconferencing.

A far more significant step would be the internalisation of the external costs of transport, in particular with respect to the greenhouse burden, the cost of speed and the cost of sprawl. Enforcement of modern ICT and subsidising transport, particularly high-speed and long-distance transport, will likely jeopardise the potential benefits of ICT applications. Without increasing costs ICT might even stimulate more transport than save. Raising transport cost on the other hand will support the process of substitution by telework and teleconferencing, while mitigating compensatory travel.

Business decision-makers should consider telework and teleconferencing as ways in which their companies can reduce transport costs and transport use. However, these benefits do not occur automatically. Once telework is used on a frequent basis, some standard procedures need to be developed. Training of teleworkers, developing their special skills, responsibilities, etc., may be necessary. Additionally, plans and standards for work organisation, including work flow and the spatial and temporal distribution of labour, are essentials. From a transport perspective, the prevalence of work at one place during each day is crucial when one has reducing transport use in mind. Also, the social framework conditions should be clarified and considered on an individual basis. Additionally, business could make use of integrated travel plans[121] that include telework and teleconferencing as options.

Employers as well as public transport providers should offer job tickets customised to the needs of teleworkers. Today, commuter tickets with special low fares are mostly oriented to the standard working situation with five days commuting per week. Using such tickets only two or three days per week, easily cannibalises the benefits. Other ticket formats may better meet the needs of teleworkers, e.g. tickets valid 10 days per month.

Surveys could be conducted to determine which kinds of tickets best suit teleworkers. Therefore, the **scientific community** is asked to do more research on the interrelations between changing living and working places and different kinds of telework, using long-term panel surveys with panels big enough and appropriately chosen to give representative results. Until now, research into whether people will move further away from their workplace as a result of telework, has only looked at the issue from a short term perspective. More emphasis should be given to the long-term reactions, and in particular to changes in workplace.

Detailed analyses of business travel are needed, combining analysis of travel range and frequency with the use of ICT applications like teleconferencing. For a deeper understanding of the correlation between business travel and teleconferencing, and in particular of the quantitative aspects, a more comprehensive study will be essential. To allow general findings, a sound sample basis is necessary, as individual cases may show any results.

Finally, detailed analysis of the interrelations between telework and teleconferencing on the one hand, and the development of urban space and urbanisation patterns on the other are required. Suburbanisation obviously is not primarily a result of ICT use.

[121] The integrated travel plan, a planning tool of specific relevance in the U.K., aims at a combined realisation of the appropriate means of transport to optimise particularly commuting travel to a business location.

But ICT, in particular telework and teleconferencing in combination with teleshopping, may lead to significant changes in patterns of urban distribution. A careful observation and analysis of patterns of urban distribution is essential to avoid undesired results. With respect to teleshopping, special attention should be given to the changing structures of retail trade.

6.5 Raising awareness and changing habits

Digital Europe's research has shown that habits are an important factor to consider. Consumer habits are to an increasing extent decisive in determining overall material intensity. For example, efficiency gains might be offset by rebound effects, digitised products tend to be re-materialised, business builds up additional echannels to reach their customers without reducing the traditional channels, etc. However this is not only a problem of habits, but also one of a lack of awareness of what the environmental problems connected to an esociety are.

In order to achieve the efficiencies that an esociety can bring about, the counterbalancing influences from rebound effects and other negative side-effects need to be mitigated through a broad set of **political framework conditions**. The users of eservice applications tend to re-materialise digital information. Examples are music files burned on CDs or the tendency to print out most digital documents. The case study on digital music highlighted the fact that this habit might even mean that the savings from digital distribution are counterbalanced. This indicates that habits are still very much rooted in a non-digital world. Reasons for that are manifold, whether issues like trust (is the information safe; is a back-up needed), traditions (important information needs to be filed as a print-out), habits (to work with long documents requires a print-out) and so on. For users to handle digital information without re-materialisation, esociety literacy is needed. While the younger generation will hopefully grow up with a mindset allowing them to deal with this, training and empowerment might be needed for other population groups.

Political countermeasures are needed to promote the understanding of rebound effects, e.g. regarding transport. The Internet will reframe markets, enabling companies and consumers to buy globally, which is likely to increase transport demands. Freed time through egovernment or ebusiness activities might lead to an overall increase in private transportation demands. More generally, the public sector should help to develop an understanding of the rebound effects through the support of related research.

Business can use environmental product criteria as a competitive advantage and raise awareness of greener, eco-efficient ICT devices among users. Environmental product information, ideally on a trans-national level, should not only be used, but also actively promoted. As the experience with labelling of washing machines shows, business can benefit from the use of product declarations and support an informed consumer choice. For personal computers, even though, the certification criteria for the EU eco-label (EU flower) has existed since 2001, no product carrying the label is available. Thus, further promotion and harmonisation of product declaration is needed.

Cross sectoral co-operations along the supply chain seem to be an important issue for ebusiness. This is of particular relevance to service-intensive sectors where most of the environmental effects are indirect and consumer behaviour is a decisive factor. Co-operation and information/communication strategies seem to be a promising approach to influence the environmental effects outside direct control of the ebusiness sector. Hence product or service panels, representing the important actors along the supply chain as well as other relevant stakeholders, appear to be crucial in order to improve the sector's performance. Topics of potential interest are, for example, the environmental effects of ICT equipment.

Inherent to all case studies is the fact that consumer behaviour and in particular the rebound effects, i.e. unintended negative consequences that accompany a change, are likely to influence the results in one way or another. Unfortunately, **scientific knowledge** in this field, in particular related to ebusiness, is scarce. A better understanding of the size and potential impact of rebound effects is urgently needed to further specify research results. While omitting these effects is not expected to have a large impact on results at a case study level, uncertainties connected to consumer habits render any explicit specification on the potential impacts on the macro level difficult. Of particular importance is the early integration of rebound reduction opportunities in the design phase of products and services. Research, ideally in co-operation with business, is needed to develop a sort of "early rebound check", to be integrated as a tool in the design phase.

7 References

Chapter 2

Commission of the European Communities. (2000). eEurope An Information Society for all – Communication on a Commission Initiative for the Special Council of Lisbon, 23 and 24 March 2000.

Commission of the European Communities (2001): Communication from the Commission to the Council and the European Parliament: The Impact of the e-Economy on European Enterprises: Economic Analysis and Policy Implications, COM (2001) 711 final, Brussels, 29.11.2001.

Commission of the European Communities (2002): Communication from the Commission to the Council, the European Parliament and the Economic and Social Committee and the Committee of the Regions: eEurope 2005 - An Action Plan to be presented in view of the Sevilla European Council – 21/22 June 2002, COM (2002) 263.

Commission Proposal COM(2001) 264 final. A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development.

Chapter 3

Cohen, N., (2001). The Environmental Impact of E-Commerce, In: Hilty, L. M., Gilgen, P. W., (Eds.), (2001). Sustainability in the Information Society, Metropolis-Verlag, Marburg, pp. 41-52.

EEA (1999). Making sustainability accountable: Eco-efficiency, resource productivity and innovation. European Environment Agency, Topic report No 11/1999.

Eurostat – Statistical Office of the European Communities (2000). NAMEA set of standard tables, European Communities, Luxembourg 2000.

Federal Statistical Office Germany (2001). Environmental-Economic Accounting. Material and Energy Flows, Wiesbaden 2001.

Federal Statistical Office Germany (2002): Input Output Tables 1991-2000, Wiesbaden 2002

GeSI. (2002). Sector report for the Johannesburg Summit 2002 – Information and communications technology. (Online) Available: http://www.uneptie.org/outreach/wssd/sectors/ICT/ict.htm (2002,07,15).

Hilty, L. M., Gilgen, P. W., (Eds.), (2001). Sustainability in the Information Society, Metropolis-Verlag, Marburg.

Jantzen, J., (2001). Information technology and potential positive environmental effects there of in processing industries, In: Hilty, L. M., Gilgen, P. W. (Eds.), (2001) Sustainability in the Information Society, Metropolis-Verlag, Marburg, pp. 99-106.

OECD (2000). Measuring the ICT Sector. OECD, Paris 2000.

Spreng, D., (2001). Does IT have boundless influences on energy consumption?, In: Hilty, L. M., Gilgen, P. W. (Eds.), (2001) Sustainability in the Information Society, Metropolis-Verlag, Marburg, pp. 81-90.

Weizsäcker, E. von, Lovins, A. B. & Lovins, L. H. (1997). Factor Four. Doubling Wealth, Halving Resource Use, Earthscan, London 1997.

Chapter 4

Accenture, Markle Foundation, United Nations Development Programme (2001). Creating a development dynamic – Final report of the digital opportunity initiative. available at http://www.opt-init.org/framework/pages/2.2.5.html

Aebischer, B., Huser, A. (2000). Vernetzung im Haushalt, Auswirkungen auf den Stromverbrauch. [Internet in the household: effects on the electricity consumption]. Zürich/Bern.

Arnfalk, P. (2002). Can virtual meetings replace business travel?, in: WWF, Sustainability at the speed of light.

Arnfalk, P. (2002). Information and communication technologies and business travel – Environmental possibilities, problems and implications, In: Park, J., Roome, N. (2002). The Ecology of the New Economy – Sustainable transformation of global information, communications and electronics industries, Greenleaf Publishing 2002.

Austrian Government (1995): National Environmental Action Plan. Vienna.

Barthel, Claus, Lechtenböhmer, Stefan & Thomas, Stefan. (2001). GHG Emission Trends of the internet in Germany. In Langrock, Thomas, Ott, Hermann E. & Takeuchi, Tsuneo. (2001) International Climate Policy & the IT-Sector (55-70). Wuppertal, Wuppertal Spezial 19, Wuppertal Institute.

Berkhout, F., Hertin, J., (2001). Impacts of Information and Communications Technologies on Environmental sustainability: Speculations and Evidence, Report to the OECD, Brighton, UK.

Blaschke, P. (2002). Konsequenzen für die öffentliche Verwaltung, In: Blaschke, P., Karrlein, W., Zypries, B. (2000) E-Public, Strategien und Potenziale des E- und Mobile Business im öffentlichen Bereich, Berlin et al. 2002.

Bundesministerium des Innern, Stabsstelle Moderner Staat – Moderne Verwaltung, (2001). BundOnline 2005 - Umsetzungsplan für die eGovernment-Initiative [BundOnline 2005 – Action plan for the egovernment initiative] Berlin, Dezember 2001.

Chang Yang, Jih, (n.d.). Environmental impact of e-commerce and other sustainability implications of the information economy, Working paper of the Research Group on the Global Future, Center for Applied Policy Research. Online available at http://www.cap-info.de/triangle/download/envcom.PDF

Cohen, N. (2002). E-Commerce and the environment, in: WWF, Sustainability at the speed of light, 2002.

Cohen, Nevin, (2001). The Environmental Impacts of E-Commerce, in: Hilty, L., Gilgen, P (Eds.), Sustainability in the Information Society, Marburg 2001.

Cross, John (1998). Informal Politics: Street Vendors and the State in Mexico City. Stanford University Press, Stanford. 1998.

de Soto, Hernando (2000). The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else.

Der Spiegel (2002). Internet: Der Rest der Finsternis. [Internet: the rest of the darkness]. 24, 2002.

Dettling, D. (2002). Digitales Deutschland: Das demokratische Versprechen von e-government. [Digital Germany: the democratic promise of egovernment], In: Kommune1/2002.

Eames, M. et al. (2000). E-topia? Contextual Scenarios for Digital Futures. SPRU-Science and Technology Policy Research, University of Sussex.

Eco-Cycle Commission (1997): Hallbrat Sa Klart – en Kretsloppstrategi. Kretsloppsdelegationens Rapport 1997/13. Stockholm.

Fichter, K., (2001). Sustainable Business Strategies in the Internet Economy, In: Loreny, H., Gilgen, P., (Eds.) Sustainability in the Information Society, Marburg, 2001.

Forrester Research, Inc. (2000). EMarketplaces boost B2B trade, February.

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (1998): Sustainable Development in Germany – Draft Programme for Priority Areas in Environmental Policy. Bonn, Germany.

GfK-Onlinemonitor (1999). In: Bundesministerium für Wirtschaft und Technologie. E-f@cts: Informationen zum E-Commerce. Ausgabe 01/2001.

Greenspan, R. (2002). EU B2B Expected to Explode. Online. Available at: http://cyberatlas.internet.com

Hendrickson, C. T., Matthews, H. S., Soh, D. L. (2000). The Net Effect: Environmental Implications of Ecommerce and the Logistics, Pittsburgh: Carnegie Mellon University.

Hinterberger, F., Liedtke, C. et al., (1998). Ökoeffiziente Dienstleistungen als strategischer Wettbewerbsfaktor zur Entwicklung einer nachhaltigen Wirtschaft. [Eco-efficient services as strategic competitive advantage for the development of a sustainable Economy]. Final report of the Research Network „Ökoeffiziente Dienstleistungen“.

Internet Software Consortium, www.isc.org

James, P./Hopkinson, P. (2001). Virtual traffic: e-commerce, transport and distribution, in: Wildson, James (ed.), Digital futures: living in a dot-com world, London.

Lenk, K. (2000). Dienstleistungssysteme und elektronische Demokratie. [Service Systems and Electronic Democracy] In: Schneidewind, U., Truscheit, A., Steingräber, G., (2000). Nachhaltige Informationsgesellschaft, Analyse und Gestaltungsempfehlungen aus Management- und institutioneller Sicht. [Sustainable Information Society, Analysis and policy proposal from a management and institutional point of view] Metropolis-Verlag, Marburg 2000.

Liedtke, C., Rohn, H., Kuhndt M., Nickel, R. (1998). Applying Material Flow Accounting: Eco-Auditing and Resource Management at the Kambium Furniture Workshop. Journal of Industrial Ecology, Volume 2, Number 3, MIT Press.

Manstein, Ch. (1996). Das Elektrizitätsmodul im MIPS-Konzept [Electricity module for the MIPS concept]. Wuppertal Papers, No. 51, Wuppertal Institute for Climate, Environment, Energy, Wuppertal, Germany.

Ministry of Housing, Spatial Planning and the Environment (1996): Dutch bill extending the Environmental Management Act to provide for environmental reporting (Engl. translation), The Hague 1996

Miura, H., et al., (2002): Analysis of the Effect of Local e-Government on Climate Change, In: Proceedings of The Fifth International Conference on EcoBalance – Practical tools and thoughtful principles of sustainability, Nov 6 – Nov 8, 2002. EPOCHAL TSUKUBA, Tsukuba, Japan

Office of Technology Assessment at the German Parliament (TAB) (2002). Innovationsbedingungen des Ecommerce – die technischen Kommunicationsinfrastrukturen für den elektronischen Handel. [Innovation conditions of ecommerce: the technical communication infrastructure for electronic commerce]. Background paper no. 7. TAB.

Pröhl, M. (2002). Expertin: E-Government ist Motor im Reformprozess der Verwaltungen [Egovernment is the engine of reform process of the administration offices]. IfG.CC - Institute for eGovernment. Interview available at http://www.e-lo-go.de/html/modules.php?name=News&file=article&sid=1024

Projekt Ruhr GmbH (2002). Zukunftswerkstatt Ruhrgebiet. [Future project Ruhr area]. Online available at http://www.projektruhr.de.

Reichart, I., Hischler, R., Schefer, H., and Zurkirch, M. (2000). Umweltbelastung durch Internet-Surfer, Fernsehzuschauer und Zeitungsleser [Environmental impacts of surfing the Internet, watching TV and reading a newspaper]. Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), 2000.

Reichling, M. Otto, T. (2002). Environmental Impact of the New Economy, In: Park, J., Roome, N. (Eds.) Ecology of the New Economy, Greenleaf.

Romm, J. (1999). The Internet Economy and Global Warming, The Centre for Energy and Climate Solutions.

Romm, Joseph, Rosenfeld, Arthur, Herrmann, Susan. 1999. The Internet Economy and Global Warming: A Scenario of the Impact of E-commerce on Energy and the Environment. Washington, DC: The Center for Energy and Climate Solutions.

Sarkis, J., Meade, L., Talluri, S. (2002). E-logistics and the natural environment, In: Park, J., Roome, N. (2002). The Ecology of the New Economy – Sustainable transformation of global information, communications and electronics industries, Greenleaf Publishing 2002.

Shuppan, T., Richard, Ch. (2002). Neue Verwaltungsmodelle braucht das (Flächen)Land: Verwaltungsmodernisierung mit E-Government [The country needs new administration models: modernisation of administration by egovernment], In: Technikfolgenabschätzung – Theorie und Praxis Nr. 3/4, 11. Jg., November 2002.

Stiller, H. (2002). In: Andretsch, D., Welfens, P. (2002). The New economy and economic growth in Europe and the U.S., Springer.

Swedish EPA (2000). Home shopping will save energy. Available online at http://www.swedenvironment.environ.se/no0001/0001.html#art13.

Thomas, S. (2002). www.internet.co2? GHG emissions of the Internet in Germany. Presentation at the IEA Workshop: Information and Communication Technology: the Next Challenge for Energy Systems? 21/22 February 2002, Paris. Information is based on unpublished results by Stephan Thomas and Dr. Claus Barthel, Wuppertal Institute.

Türk, V., Ritthoff, M., Geibler, J. von & Kuhndt, M. (2002). internet: virtuell = umweltfreundlich? [internet: virtual = environmentally sound?] In: Altner, G., Mettler-von Meibom, B., Simonis, U. & Weizsäcker, E.U. von (Editors), Jahrbuch Ökologie 2003. Beck, München, p. 110-123.

Türk, V., Kuhndt, M. (2002). The Resource Intensity of the Internet Infrastructure. Wuppertal Paper, in preparation.

Türk, Volker. (2001). Assessing the Resource Intensity of the Internet Infrastructure: Data Analysis for a Material-Flow Oriented Approach and First Results on Electricity Consumption. M. Sc. thesis at the Lund University, Sweden. [Online]. Available: http://www.iiiee.lu.se/ [2002, July 17].

UNESCO, COMNET-IT (n.d.): On-line Governance Survey Report - A joint UNESCO and COMNET-IT Project, n.d.

United Nations Division for Public Economics and Public Administration (2002). Benchmarking E-government: A Global Perspective Benchmarking - Assessing the Progress of the UN Member States.

United Nations, E-Commerce and Development Report 2001, Chapter 4.

United Nations Division for Public Economics and Public Administration. (2002). Benchmarking E-Government: A Global Perspective Benchmarking - Assessing the Progress of the UN Member States.

United Nations Economic Commission for Europe – Environment and Human Settlements Division. Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters. [Online] Available at http://www.unece.org/env/pp/ [2002, December 19]

United States Environment Protection Agency (USEPA). (2002). Toxics Release Inventory Program. [Online] Available: http://www.epa.gov/tri/ [2002, November 19].

van Leewen, Robert. Transport en Logistiek Netherlands: New Wine in Old Bottles – Argument in Favour of More Space for Road Haulage to Accomodate the Growth of New Economy; paper presented at the Joint OECD/ECMT Seminar ”The Impact of E-Commerce on Transport, Paris 5/6 june 2001.

VDI Nachrichten (30. März 2000). Netzknoten sind wahre Stromfresser [Internet nods are extreme electricity consumers].

Vidigal, L. (1999). INFOCID - A single window for citizenship in Portugal, In: Democracy and Government On-Line Services - Contributions from Public Administrations Around the World - a G8 GOL publication. Online available at http://www.statskontoret.se/gol-democracy/portugal.htm

Vogt, Walter, Glaser, Walter et. al. (2002): Verkehrliche Auswirkungen von Teleshopping und Telecommerce auf die Mobilität privater Haushalte (transport effects of teleshopping and telecommerce on the mobility of private households), Stuttgart 2002, Universität Stuttgart, Veröffentlichungen aus dem Institut für Straßen- und Verkehrswesen (University Stuttgart, publications from the Institute on Roads and Traffic), p. 27.

Westholm, H. (2000). Perspektiven einer virtuellen Demokratie, [Perspectives of a virtual democracy] In: Schneidewind, U., Truscheit, A., Steingräber, G. (2000). Nachhaltige Informationsgesellschaft, Analyse und Gestaltungsempfehlungen aus Management- und institutioneller Sicht. [Sustainable Information Society, Analysis and policy proposal from a management and institutional point of view] Metropolis-Verlag, Marburg 2000.

White et al. (1999). Servicising: A quiet transition to Extended producer responsibility, In: Mont, O. (1999). Product service systems. IIIEE, Lund University.

Wilsdon, J. (ed.) (2001). Digital Futures: living in a dot-com world, Earthscan, London.

WTO (2000). Tourism Highlights 2000, Second Edition August 2000. Extracts available online at http://www.worldtourism.org/frameset/frame_market_data.htm

WTTC (2001). Tourism Satellite Accounting Research – World. Available online at http://www.wttc.org/ecres/pdfs/WLD.pdf

Wuppertal Institute, (2002). Review of Eco-Efficiency Concepts in Europe – Towards an Application of European-Based Policies on Material Flows and Energy to Japanese Sustainable Development Policies, Final Report, January 2002.

www.globalreporting.org

Zypries, B. (2002). BundOnline 2005: Auf dem Weg zum dienstleistungsorientierten modernen Staat [BundOnline 2005: On the road to a service orientated modern state], In: Blaschke, P., Karrlein, W., Zypries, B., (2000). E-Public, Strategien und

Potenziale des E- und Mobile Business im öffentlichen Bereich [E-Public, strategies and potentials of e- and m-business in the public sector], Berlin et al., 2002.

Chapter 5

Arnfalk, Peter (2002): Virtual Mobility and Pollution Prevention, Lund.

Bundesministerium für Bildung und Forschung, Deutschland, quoted by Bildungszentrum der Wirtschaft im Unterwesergebiet (2000) Leitfaden für die Einführung von Telearbeit [Guideline for the implementation of telework], Bremen

Cabinet Office: e-government. A strategic framework for public services in the Information Age, Crown copyright (UK) 2000

Department for Transport, Local Government and the Regions (2000): Transport Statistics Bulletin: National Travel Survey: 1997/99 Update, London 2000

Deutsches Institut für Wirtschaftsforschung, (2000) Verkehr in Zahlen 2001/2002 [German Institute for Economic Research, Berlin: Transport in Figures 2001/2002], ed. by the German Federal Minister on Transport.

Deutsches Institut für Wirtschaftsforschung (2001) DIW Wochenbericht 34/2001, Berlin

Empirica GmbH (2000) Benchmarking Progress on new ways of working and new forms of business across Europe, Final Report, Bonn

Empirica GmbH (2000) Benchmarking telework in Europe 1999, Decision Maker Survey (DMS)", Bonn;

Empirica GmbH (2000) Telework data report (population survey) - ten countries in comparison -, Bonn;

European Commission (1999) Status Report on European Telework, New Methods of Work, available online: http://eto.org.uk

European Commission (2000) Status Report on new Ways to work in the information society, available online: http://eto.org.uk

European Commission (2001) Status Report on New Ways to Work in the Knowledge Economy, available online: http://eto.org.uk

European E-City Award 2002, at: www.eec-award.com, and: www.eec.pixelfarmers.com

IEA, International Energy Agency (1997): The link between Energy & Human Activity, Paris

ITAC, International Telework Association & Council, www.telecommute.org. (2002, July 7th)

Jönson, Gunilla & Johnsson, Mats (2001). Electronic commerce and distribution systems. Lund Institute of Technology.

Kloas, Jutta, Kuhfeld, Hartmut (1996): Entwicklung des Personenverkehrs in der Bundesrepublik Deutschland, in: DIW-Wochenbericht 37/96 [Development of Passenger Transport in Germany, in: Weekly Reports 37/1996 from the German Institute for Economic Research], Berlin

Kloas, Jutta, Kuhfeld, Hartmut (2002): Stagnation des Personenverkehrs in Deutschland, in: DIW-Wochenbericht 42/02 [Stagnation of Passenger Transport in Germany, in: Weeekly Reports 42/2002 from the German Institute for Economic Research], Berlin

Merz, M. (2002) E-Commerce and E-Business, Heidelberg, second Edition

Miura, Hiroshi et al., Research Institute, Mitsui knowledge Industry Co., Ltd,, Miura-h@hrm.mki.co.jp, and Miyamoto, Shigeyuki et al., NEC Corporation, Environment

Technology Laboratories, s-miyamoto@ax.jp.nec.com: Analysis of the Effects of Local E-Government on Climate Change

Nerlich, Mark. (2001). Tabellenband der Telemobilitätsstudie 2001 (volume: tables of the study “telemobility”), Hamburg-Harburg.

Postel-Vinay, Gregoire (2002): Can telework save energy? A French outlook, paper presented at the IEA-conference ”The Future Impact of Information and Communication Technologies on the Energy System”, Paris, February 21-22, 2002; presentation available over the IEA-homepage

Regionales Rechenzentrum Erlangen (1999) Telekonferenz der Bayerischen Rechenzentrumsleiter [teleconference of the heads of the Bavarian computer centres), Erlangen

Rheinisch-Westfälisches Institut für Wirtschaftsforschung e.V. (2000) Wachstums- und Beschäftigungspotentiale der Informationsgesellschaft bis zum Jahre 2010, [growth and job potentials of the information society until 2010], Essen

Schafer, A (2000) MIT Center for Technology, Policy & Industrial Development, and MIT Joint Program on the Science and Policy of Global Change: Modeling Global Mobility – World Passenger Transport Through 2050. Presentation at the Transportation Vision 2050 Futurist Workshop, Doubletree Inn at Southcenter Mall, Seattle 2000, Sheet 6.

Schafer, A., Victor, D. (2000): The Future Mobility of the World Population. Transportation Research A, 34 (3), pp. 171 – 205.

Schallaböck, Karl-Otto (1996): Verkehr und Zeit (travel and time), in: Jürgen P. Rinderspacher: Zeit für die Umwelt [time for the environment], Berlin 1996, pp. 175 – 212

Schallaböck, Karl-Otto, Petersen, Rudolf (1999): The Spread of Congestion in Europe, in: ECMT - Round table 110 „Traffic Congestion in Europe“, Paris (OECD)

Shipper, L., Fulton, L. (2001): Driving a Bargain? Using Indicators to Keep Score on the Transport-Environment-Greenhouse Gas Linkages. Washington, 75th Annual Transportation Research Board Meeting

Statistisches Bundesamt (federal statistical agency, Germany). Statistisches Jahrbuch 2002 (statistical yearbook 2002).

Van Leewen, Robert, Transport en Logistiek Netherlands: New Wine in Old Bottles – Argument in Favour of More Space for Road Haulage to Accomodate the Growth of New Economy; paper presented at the Joint OECD/ECMT Seminar ”The Impact of E-Commerce on Transport, Paris 5/6 June 2001.

Vogt, Walter, Denzinger, Stefan et al. (2001): Auswirkungen neuer Arbeitskonzepte und insbesondere von Telearbeit auf das Verkehrsverhalten [effects of new concepts of work, and in particular of telework on travel behaviour], Bremerhaven 2001.

Vogt, Walter, Glaser, Wilhelm, et. al. (2002): Verkehrliche Auswirkungen von Teleshopping und Telecommerce auf die Mobilität privater Haushalte [transport effects of teleshopping and telecommerce on the mobility of private households], Stuttgart 2002, Universität Stuttgart, Veröffentlichungen aus dem Institut für Straßen- und Verkehrswesen [University Stuttgart, publications from the Institute on Roads and Traffic].

Wissenschaftliches Institut für Kommunikationsdienste GmbH (2001) Entwicklungstrends im Telekommunikationssektor bis 2010 [future trends of telecommunication until 2010], Bad Honnef.